R/E RESEARCH & ENGINEERING

FOR RESEARCH & DEVELOPMENT MANAGERS

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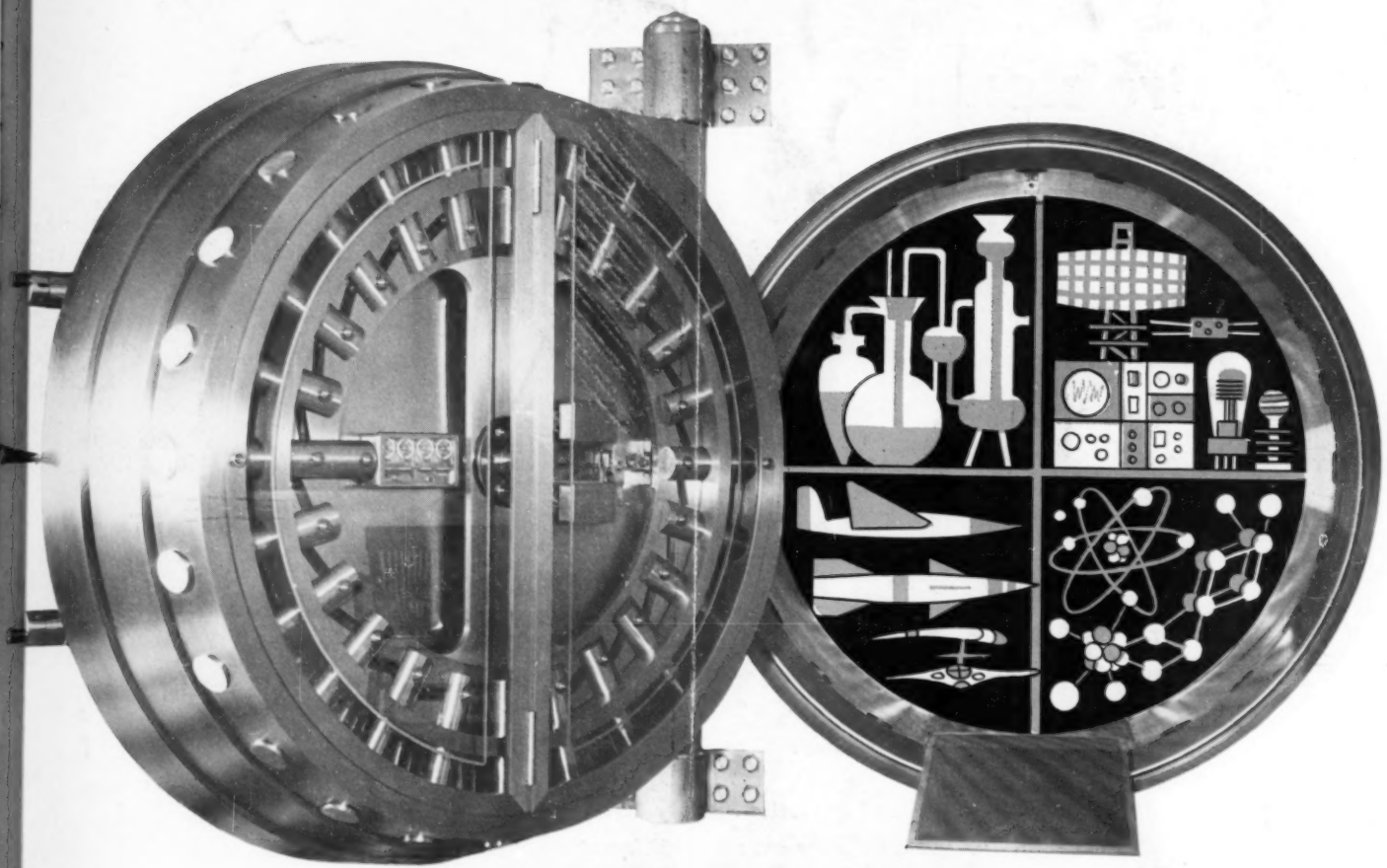
RESEARCH AND DEVELOPMENT



For PROFIT

REPORT ON NATIONAL INDUSTRIAL RESEARCH CONFERENCE

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DESIGN TIME AND MONEY • Punched Cards for Control

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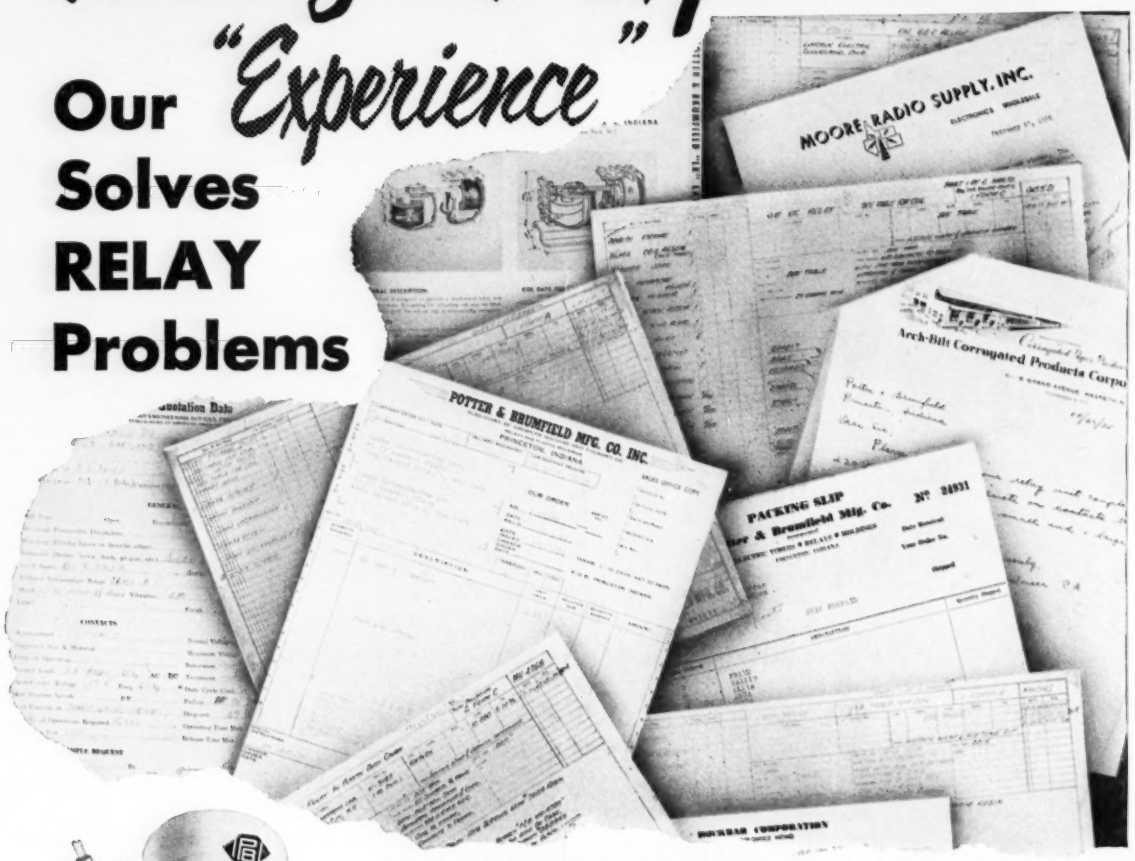

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JUNE 1956
VOL. II, NO. 6

RESEARCH & ENGINEERING

THE MAGAZINE FOR RESEARCH AND DEVELOPMENT MANAGERS

features

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In the next few decades food preservation and chemical processing by powerful gamma sources are likely to become commonplace.

DESIGN TIME AND MONEY: Punched Cards for Control
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Burndy Engineering has come up with a system of mechanized project control that facilitates decision-making, and helps in estimating costs and duration for new design projects.

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New Magnetic-Tape Control for Short-Run Machine Tools. *There's a big market for "Digimatic", a new automatic machine tool control designed for medium-sized job shops concentrating on short runs.*

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No Moving Parts in Air Filter. *No oil pump is required for this air filter for engines, compressors and blowers.*

Rocket Thrust Measured by Giant Transducer. *Load cell takes up to 250,000 lb in compression or tension in measuring rocket thrust.*

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Last April, Armour Research Foundation of Illinois Institute of Technology sponsored a National Industrial Research Conference; the theme: "Research for Profit". With their consent we have modified this theme to "Research and Development for Profit" and are devoting the feature section of this issue to just that subject although, strictly speaking, the main editorial objective of each issue of RESEARCH & ENGINEERING could be said to be just that. The difference between this issue and all others is that we are taking the trouble to be explicit.

For this reason we should in all fairness answer two questions: What do we mean by "profit"? What do we mean by "research and development"? Because profit at times can be a highly abstract, culturally indeterminate quantity —each of us is entitled to his own idea of what is and is not profitable—we shall leave its definition up to you, with the full knowledge that you may have doubts about a definition adequate for presentation to stockholders. For our purposes we shall concentrate on the definition of research and development.

As a human function and a corporate activity, research and development has undergone a significant and not a completely agreed upon change in meaning during the past 15 years. Attempts to come up with workable, usable definitions have spawned a variety of prefixes: pure, fundamental, basic, applied, end-use, frontier, committed, university, government and industrial. But of all the different approaches the one that appears to be most usable is that developed by the Harvard Graduate School of Business Administration in cooperation with the Department of Defense, the National Association of Manufacturers and the Industrial Research Institute. This definition was used as the basis for evaluating research and development, research and development costs and research and development personnel in a survey conducted for the National Science Foundation by the U.S. Department of Labor, Bureau of Labor Statistics (**R/E** *April, '56, pp 18-22*).

We prefer to modify their introductory statement (leaving out reference to the biological sciences and medicine) so that for our purposes:

Research-Development **includes activities carried on by persons trained, either formally or by experience, in the physical and engineering sciences if the purpose of such activity is to do one or more of the following things:**

(1) Pursue a planned search for new knowledge, whether or not the search has reference to a specific application.

(2) Apply existing knowledge to problems involved in the creation of a new product or process, including work required to evaluate possible uses.

(3) Apply existing knowledge to problems involved in the improvement of a present product or process.

Note that the definers evidently preferred to tie "research" more closely to "development" by using a dash between the words instead of an ampersand and that no effort was made to prefix or otherwise elaborate on the word "research". It is also signficant that the definers were not satisfied with this connotative definition but felt that the actual activities or operations needed more clarification. And so they continued with:

The following kinds of activity are included:

(1) Laboratory scale activity.

(2) The design and operation of pilot plants or semiworks plants so long as the *principal* purposes are to obtain experience and to compile engineering and other data to be used as follows:

(a) in evaluating hypotheses,

(b) in writing product formulas or in establishing finished product specifications,

(c) in designing special equipment and structures required by a process, and

(d) in preparing operating instructions or manuals.

(3) The engineering activity required to advance the design of a product or a process to the point where it meets specific functional and economic requirements and can be turned over to manufacturing units. The design, construction, and testing of pre-production prototypes and models and "engineering follow-through" in the early production phase is included. The development of designs for special manufacturing equipment and tools is included but tool-making and tool tryout are *not* included.

(4) The preparation of reports, drawings, formulas, specifications, standard practice instructions or operating manuals, and other media for transmitting to operating units information obtained from the above activities. However, the production of detailed construction drawings or manufacturing blueprints is *not* included.

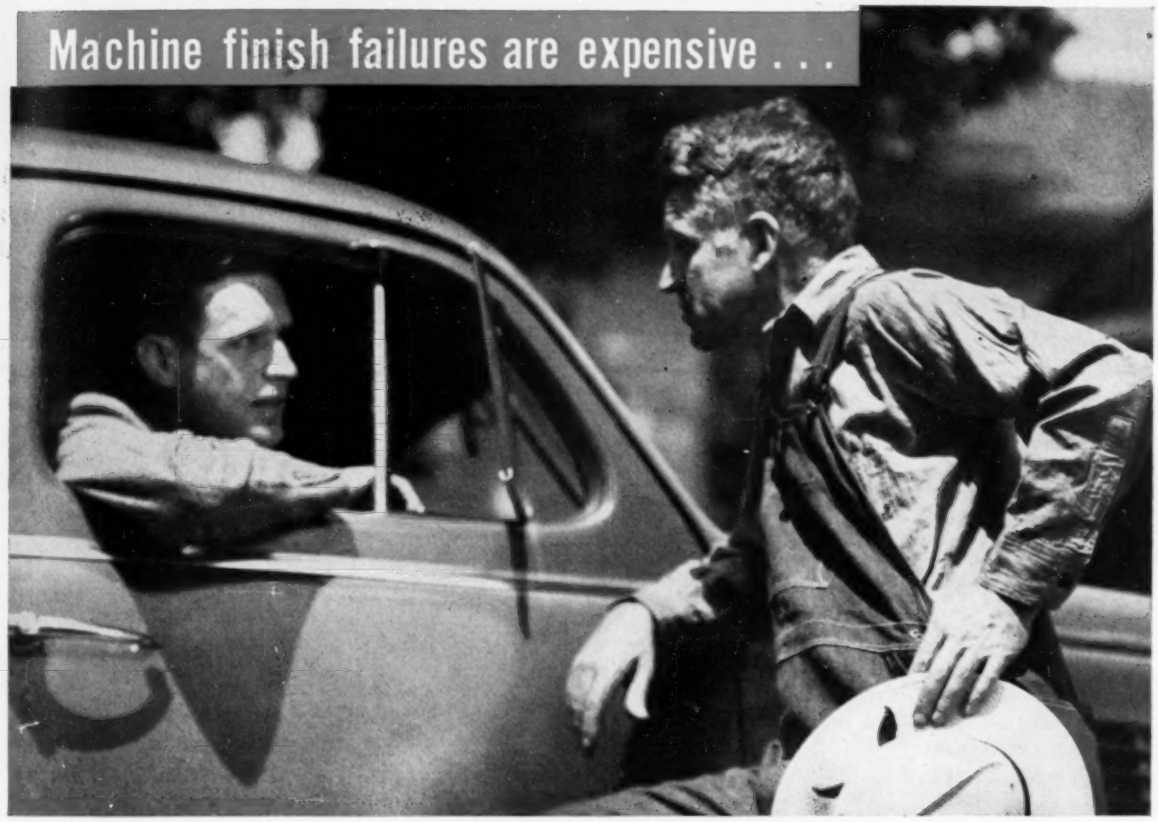
The question, "When does development end and production begin?" is often asked. If the primary objective is to make further improvements on the product or process, then the work comes within the definition of research-development. If, on the other hand, the product or process is substantially "set," and the primary objective is to develop markets or to do preproduction planning, or to get the production process going smoothly, then the work is no longer research-development.

The definers continued by listing other types of activities not considered research-development. No doubt many of you may disagree with not only some of the included activities above but with some of the excluded activities not presented here. Nevertheless, of those brought to our attention, this approach is the best to date. Undoubtedly, the next year or next decade will bring more changes and more agreement.

In the meantime, this month's feature section gives you a roundup of who said what at Armour's "Research for Profit" meeting; technical and economic data on what will be a new and important industry within a very few years; and a simple but useful method on how one company uses punched cards to keep track of how much time and money have been expended on R & D projects. We hope you will find these and our other pages profitable reading.

Harold C. Buchbinder
EDITOR

Machine finish failures are expensive . . .



"If you people would do a better paint job to start with, you could save yourself some of these service trips."

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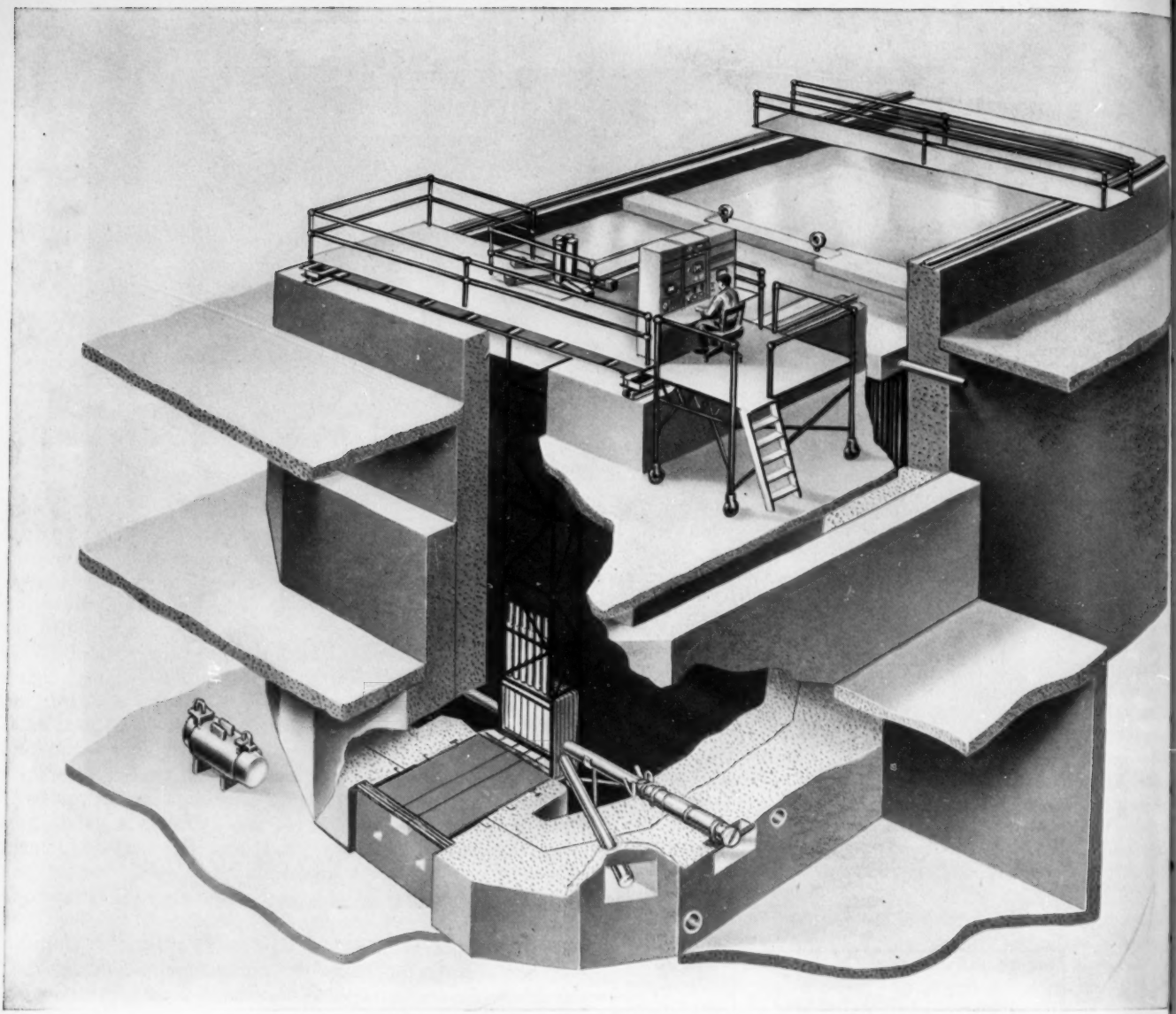
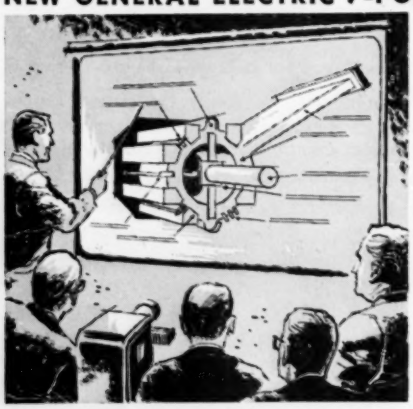


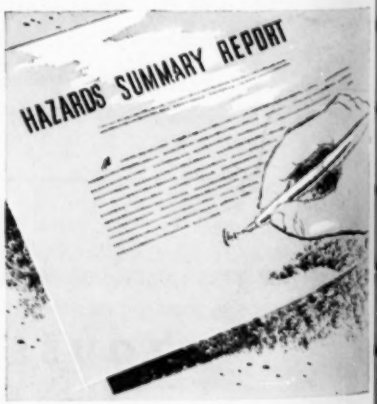
SWIMMING POOL REACTOR, one of three G-E research reactors available under the 7-point program, is designed to produce large quantities of neutrons. Its flexibility, safety features, and high flux potential appeal to universities and research organizations.

NEW GENERAL ELECTRIC 7-POINT PROGRAM:



1 REACTOR SPECIFICATIONS are prepared to meet your research requirements. These include details on core, control, and reactor components.

2 BUILDING STUDY also includes complete co-ordination of all plans for the many facilities required in the reactor and laboratory buildings.



3 HAZARDS SUMMARY REPORT: We help you prepare study for submission to AEC Division of Civilian Application.

FOR MORE INFORMATION CIRCLE 4 ON PAGE 48

How General Electric can help you enter advanced nuclear research fields

New G-E 7-point program simplifies procedure for obtaining a nuclear research reactor

There is more work involved in obtaining a nuclear reactor for advanced research than simply ordering one. Specific research requirements must be determined beforehand, an appropriate design selected, and necessary AEC construction permits and licenses obtained. Other essential steps are covered in the program outlined below.

NEW GENERAL ELECTRIC 7-POINT PROGRAM is a plan designed to materially aid you in putting a research reactor to work. Through this program you can obtain any one of three General Electric research reactors: The Swimming Pool Reactor, Heavy Water Research Reactor, or the Nuclear Test Reactor.

FOR MORE INFORMATION on these three research reactors and the new General Electric 7-point program, write for bulletin GEA-6326, General Electric Company, Section 191-1B, Schenectady 5, N. Y.; or contact your nearest G-E Apparatus Sales Office. Outside the U.S. and Canada, write to: International General Electric Co., 570 Lexington Ave., New York, N. Y.

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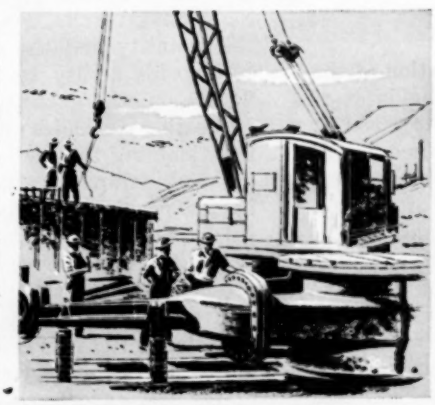
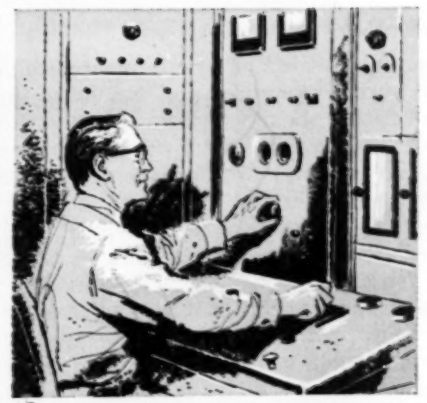
4 MANUFACTURE OF REACTOR is accurately co-ordinated with other construction plans, thereby assuring centralized project scheduling.



5 REACTOR INSTALLATION is supervised at the site by the men who have followed the design and manufacture of the complete system.

FOR MORE INFORMATION CIRCLE 4 ON PAGE 48



6-7 START-UP AND SERVICE under supervision of experienced personnel is added assurance that proper operation of your system will be maintained.

Developments

Rating Your R&D Supervisors

One of the most onerous chores for many R&D managers is the semi-annual (or annual) review and appraisal of supervisory job performance. How to go about it and exactly what to say in constructively criticizing such people sometimes becomes acutely distasteful to those with responsibility for this task. Nevertheless, it is a job that must be done in any progressive research and development unit.

George W. Howard, who heads the Technical Service Department of the Engineer Research and Development Laboratories at Fort Belvoir, Virginia, describes one way to minimize the difficulty of reaching a common ground for discussion with subordinate managers. The ERD labs have adopted and put into use a "Group Appraisal' or "Appraisal Committee" system for discussing with the young R&D administrator his job performance.

The appraisal system is one part of an Executive Development Program at the ERD labs which has included such other features as a concentrated lecture course in management improvement; a lecture series by experts in particular management fields; case studies; and a training course in Creative Thinking.

Elements of the Appraisal

The appraisal consists of a performance evaluation of the individual by his supervisor *and* two other individuals of the same relative standing as the supervisor. Approval of improvement plans for the individual (which come out of the appraisal meeting) are dependent upon (1) the committee that appraises the immediate superior of the appraisee and (2) discussion of the appraisee's evaluation with the immediate superior. This results in the development program for an individual being known not only to the people that appraised him, but also to those that appraise his supervisor.

Efforts are made to get as many managers as possible into the appraisal program. Organization at the ERD labs is by Departments, Branches and Sections, and so the Department Chiefs, Branch Chiefs and Section Chiefs (a total of 176) are included in the program. Appraisals start at the lower echelon, and a three-man committee meets with the individual being appraised to review with him the people in his unit that have been previously appraised. In the case of Section Chiefs, there are no reviews of previously appraised people. However, extension of the appraisal downward to individual project engineers and scientists is being considered.

Appraisal Considerations

The appraisal group consists of three—the immediate supervisor as chairman, and two individuals chosen by the person being appraised. In evaluating performance the following is considered:

- Results of the appraisals (if any) conducted by the appraisee
- What the appraisee proposes to do for his people with regard to their future development
- What has been accomplished on the approved program since the appraisal.

After presenting a review of the appraisals of his own subordinates, the person being appraised leaves the meeting, the three panel members then consider his job performance and operations. If there are no appraisal reviews to be presented, it is unnecessary for the appraisee to appear before his committee.

In the appraisal, consideration is given to job performance, personal qualifications, and the individual's potential within the organization. Suggestions are made for future development and thought is given to the current status of the individual within the organization.

The Appraisal Check Sheet

In considering the performance of the individual, the panel uses a check sheet. However, their evaluation of the appraisee is not limited by this sheet. They are chiefly interested in what kind of results he obtains and how he goes about getting these results. In appraising his facility for getting results, consideration is given to such items as the quantity and the quality of the individual's personal output, his ability to write clearly and factually, his influence on others, the morale in his group, his effectiveness in meeting schedules and his regard for operating expenses. In examining the methods through which he accomplishes his work, interest is centered on his ability to plan, organize, handle people, supervise and select good personnel. Careful consideration is also given to his ability to orient and instruct new employees, to develop people, and to lead conferences.

After considering the man's performance, his personal qualities are next taken up. Qualifications of the individual discussed in this phase of the appraisal are his knowledge of the job, experience, character and deportment. Also reviewed are his dependability, health, appearance, judgment, initiative and ambition. His loyalty is considered as well as his manner of giving and accepting criticism. After examin-

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FOR MORE INFORMATION CIRCLE 5 ON PAGE 48

ing these qualifications carefully, two points are stressed by the committee: (1) the strongest single characteristic of the individual and (2) his greatest single weakness. It is mandatory that a weakness be noted.

Gauging Potential

Following this review the individual's potential is next considered. Does he have potential beyond his encumbent position? What position can he fill? Does he need further training to fill a more important position? Answers to these questions should provide a specific guide to the individual as to where he is going in the organization. If this cannot be given, it should be possible to state definitely what the appraisee must do to qualify himself for further consideration for promotion. One of the most important points in favor of this course of action is that it does not represent one man's opinion, but rather that of a team which the appraisee himself has selected. Also, every point must have unanimous approval of the entire appraisal group or it is not included.

Presenting Appraisal Results

A practical course of action to improve the appraisee's effectiveness in his present work results from the appraisal; it is now ready to be presented to him by his immediate superior.

The counseling performed by the immediate superior is, of course, most important. The proper time and place must be selected with care; it should be planned so that interruptions do not occur to prevent the appraisee from having any questions left unanswered. "Couch time", as these counseling periods are sometimes called, should be arranged by the superior to gain the appraisee's confidence in the best manner possible.

During the interview the individual's responsibilities the conclusions of the Appraisal Committee are revie Why these conclusions were reached is always impor for the supervisor to explain to the appraisee. A revie also included of the individual's personal data sheet w covers his education and experience and is directly conne with the committee's conclusions.

The Importance of Self-Appraisal

It is difficult to determine how much a man can get f a program of this type, since it is only through self- praisal after counseling that the full results of the prog will have effect. Getting individuals to review their job performance objectively is not always easy. But thro counseling and various developmental aids they can be couraged to make the most of a careful review of the praisal.

Hermetic Sealing Improved

Coating nickel with ceramic cuts diffusion of hydr through it by a factor of 20. Otherwise hermetically se systems could be improved by such coatings. The investi tion leading to this conclusion was made by J. R. Cu and R. W. Dixon of the National Bureau of Standards.

When a previous NBS study of the creep rates of me at high temperatures showed a difference in the rate air and hydrogen atmospheres, the latest investigation w initiated. Diffusion tests established that an NBS A- ceramic coating can reduce the diffusion rate through specimen to at least 1/20 of the rate through bare nic even though the coating is only about 1/40 as thick as tubing wall.

New Magnetic-Tape Control for Short-Run Machine Tools

Based on market analyses by a manufacturer and independent firm, a new automatic machine tool con known as the "Digimatic" has been developed and marke The device was designed for medium-size job shops conc trating on short runs. Controlled by magnetic tape, it w developed by Electronic Controls Systems, Inc., a L Angeles affiliate of Stromberg-Carlson.

According to Jim Beveridge, our West Coast Correspo ent, the analysis revealed a big market for this sort control. Aircraft companies have long grappled with t problem of complicated precision parts that require e pensive tooling, but where short runs, lead time, hi productivity and flexibility are still of major concern. addition, the analyses showed that the potential consum had a great reticence to release his drawings and desig to outside concerns for proper encoding and preparation the memory medium. Distrust in the mathematicia ability to appreciate the impact of his encoding on act machining operations appeared to be a major area friction. Efficiency of operation through clever and uni tooling techniques are the stock in trade of a small job sh If many of these shops have to depend on the same orga zation to prepare their tapes, their primary means competition would be placed in jeopardy, according to t surveys. The Digimatic and most similar devices offer t means of preparing the tape in the same shop where t control is employed.

(Continued on page 1

Automatic Recording — Mass Collecting Differential Refractometer

Limiting sensitivity 3 x 10^{-6}

The recorder pen indicates refractive index difference. The recorder chart movement is controlled by the mass (volume) of sample passed. A valuable instrument for qualitative and quantitative analysis.

This instrument is also available in a continuous process model for differential refractive index plotted against time.

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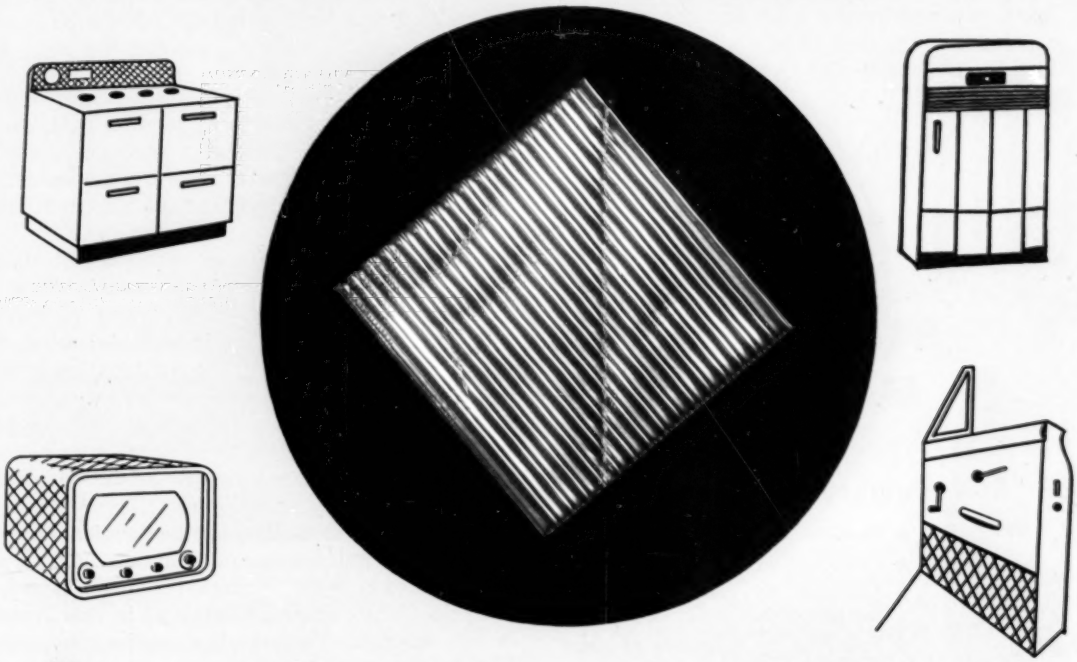

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FOR MORE INFORMATION CIRCLE 8 ON PAGE 48

While the management of Electronic Controls Systems recognizes that labor is uneasy about machines like Digimatic and may require some "education" to accept them, there was little concern expressed on this score.

Developmental efforts leading to the Digimatic were focused on a system that could be operated entirely from within the shop by available personnel with but little added training. The device was to be simple, very flexible and require a minimum of extra equipment at the machine tool itself. The resulting device consists of two units: a high-speed decimal computer and a control unit that controls the three feed axes of the tool.

Digital data is fed directly into the computer by an operator reading the blueprint. Input is through a modified 10-key board. Programming normally would be handled by a Methods Planner who would require little special training to learn how to incorporate the concept of numerical control of complex machine tools. Conversion to a binary system is not required. Data required by the computer are no more complicated than defining the beginning and ending points of a straight line or mathematically known curve referred to some datum point. The computer interpolates all intermediate points so that continuous information will be fed to the machine tool controls. Contours can be milled under control by the Digimatic. True circles and not chord approximations are generated.

Upon playback, the magnetic tape controls the operation of the machine tool's servomotors. Transducers sensing position along each of the three axes supply information to close the servo loop.

One methods planner operating one computer could prepare encoded tapes for many machines. In addition, one prepared tape could be used to operate many machines making the same part. Identical parts could be produced in machine shops a continent apart simply by providing duplicate tapes. The tapes can be forwarded quickly by mail, or in a real emergency, transmitted over telephone cables like a phone conversation. Competing devices use punched paper tape, punched steel tape and punched endless loops of Mylar as well as magnetic tape for the memory medium.

Open Sesame

Chemical terminology is frighteningly obscure to the non-chemist, but it can be of itself a valuable R & D tool. The full chemical name of a substance will indicate, to the chemist, its structure, its general chemical properties and often the characteristic that makes it unusual. Consider for example, the case of sesamolin.

The chemical structure of sesamolin (isolated from the oil of sesame seed) has just recently been determined. This complex compound is the most powerful synergist known for pyrethrum, an insecticide; when the two are mixed in equal quantities, the combination is 31 times more powerful than pyrethrum alone (synergy: combined effective action of two or more drugs). By comparison, commercially available synergists, used in even higher concentrations, will produce at best a 12-fold increase in effectiveness. A clue to the exceptional value of sesamolin is found in its structure as outlined in its chemical name.

The full chemical name of sesamolin is 2-(3, 4-methylenedioxyphenoxy)-6-(3, 4-methylenedioxypheny)-*cis*-3,7-dioxabicyclo (3.3.0) octane. Contained in this formidable array is the essential clue—methylenedioxyphenoxy. It is true that only a chemist would recognize the importance of the clue, but it is worth noting that he can do so, if provided with adequate nomenclature. It is precisely with the tool of nomenclature that the chemist can manipulate the scientific literature, cataloguing and classifying structure and performance, and identifying unique structural groups with their physical properties and chemical activity. Frequently, new effects can be predicted from changes in the basic structure of a chemical—and, for this to be possible, structures must be described in precise terms.

Rules of Chemical Nomenclature

The non-chemist may not realize it but definite rules of procedure, as rigid as *Robert's Rules of Order*, have been established to help the chemist classify his discoveries and communicate the results of his work, without fear of misunderstanding, at least by other chemists.

First, some ground rules. The fundamental building block in organic chemistry is the hydrocarbon—a unit comprising varying numbers of carbon and hydrogen atoms. Some hydrocarbons link together in a straight line; these are, in order of their increasing complexity, methane (CH_4), ethane (C_2H_6, propane (C_3H_8), butane (C_4H_{10}), pentane (C_5H_{21}), hexane $C(_6H_{14}$), and so on. Beyond butane, the

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FOR MORE INFORMATION CIRCLE 9 ON PAGE 48

NEW PLUG-IN UNIT

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...with Tektronix Type 541 and Type 545 Oscilloscopes

Response of both channels to the same signal. A 0.6-μsec pulse is displayed on alternate 0.1-μsec/cm sweeps of the Type 545 Oscilloscope with the Type 53/54C Plug-In Unit.

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The Type 53/54C is completely interchangeable among Tektronix Type 540-Series and Type 530-Series Oscilloscopes. When used with the Type 531 or Type 535 Oscilloscope it provides better overall passband and risetime characteristics (dc to 10 mc, 0.035 μsec) than its predecessor, the Type 53C.

Type 53/54C Plug-In Unit Characteristics

VERTICAL RESPONSE

With Type 541 and Type 545 Oscilloscopes
Passband—dc to 24 mc
(3 db ± ½ db down at 24 mc)
Risetime—0.015 μsec

With Type 531 and Type 535 Oscilloscopes
Passband—dc to 10 mc
Risetime—0.035 μsec

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20 μμf direct, 8μμf with 10x probe (P410)—as little as 2.5 μμf with 50x accessory probe.

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FOR MORE INFORMATION CIRCLE 10 ON PAGE 48

AIRBORNE COMPONENTS
IN MINIATURE

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Kearfott 3" Vertical Gyro measures only 3"x3"x4" and weighs 3 pounds. It offers the same accuracy and dependability as its predecessor, three times its volume and weight.

CHARACTERISTICS

2 degrees of freedom, accuracy 15 minutes max. of ½ cone angle, and erection rate 3°/minute — normal. Erection time — 30 secs max. from any position.

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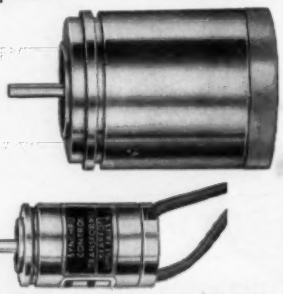
Kearfott (Penny Size) Synchros offer a reduction in diameter from 1.5 inches to .75 inches and in weight, from 5 oz. to 1.75 oz. In spite of this reduction, accuracy has been improved from 15 minutes to 10 minutes max. error from EZ. *Available as transmitters, control transformers, resolvers and differentials.*



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SHOWN 3/4 SIZE

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FOR MORE INFORMATION CIRCLE 12 ON PAGE 48

names relate simply to the number of carbon atoms present; the first four in the series owe their names to sources of long familiarity. Methane, for example, comes from the Greek *methy* (wine) and *'hyle* (wood); ethane from the Greek *aithein* (to burn, or kindle); propane form the Greek *protos* (first) and *pion* (fat); and butane from the Latin *butyrum* (butter).

Hydrocarbons with a Ring Structure

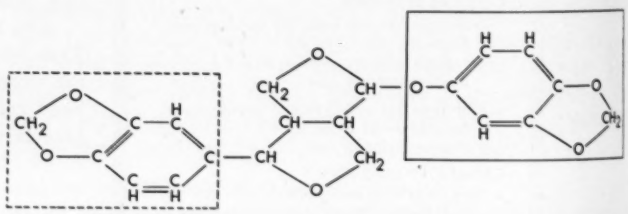
Another basic sequence of hydrocarbons comprises those that arrange themselves in a ring structure. The simple six-membered ring, benzene, C_6H_6, derives its name very indirectly from the Arabic; the name for the two fused benzene rings, anthracene, $C_{14}H_{10}$, only slightly less directly from the Greek *anthrax* (coal).

To the root syllables meth–, eth–, etc., are added modifiers that describe the chemical activity of the compound built up from the root stock. For example, if an H in the basic hydrocarbon is supplanted by OH, we get an alcohol: methane → methan*ol*. To get an acid, one must modify a hydrocarbon group on the end of a long chain, replacing three of its H's by an OH and an O: *but*ane → *butyric* acid. Some modifiers are prepositions; cyano– indicates that one of the H's has been replaced by CN: *cyano*-ethyl, for example.

Sesamolin Explained

With an adequate vocabulary based on such principles in hand, one may "read" the chemical name of sesamolin quite simply. The name of the root hydrocarbon is usually found near the end of chemical names; in this case, the root *octane* means that the basic chain consists of eight carbon atoms. *Bicyclo* indicates that these atoms are joined to form a 2-ring structure, and *dioxa* means that two of the carbon atoms in the basic 8-atom chain have been replaced by oxygen. *Phenyl* and *phenoxy* show the presence of the six-position ring structure characteristics of benzene (or, less commonly except in word combinations, *phene*). Methylenedioxy establishes that a single carbon atom (from *meth*ane) is joined to each of the phenyl rings through two oxygen atoms. The numbers in the full chemical name tell where in the structure the modifiers are attached. *Cis* describes a more subtle variation in the spatial arrangement of the double ring than can be expressed otherwise.

Thus, from the full chemical name, the trained chemist can write the structure of the sesamolin molecule as:



Both from the structure and the name, one can infer the reason why sesamolin is such a remarkable synergist. The methylenedioxyphenyl fragment (within the dotted lines) is found in the most effective pyrethrum synergists, but it is the methylenedioxyphenoxy variant that distinguishes sesamolin from other members of the family. The difference, subtle on the surface but responsible for the unusual insecticidal activity, lies in the means (an oxygen atom) by which the methylenedioxyphenyl structure is attached to the remainder of the molecule. Therefore, this is the variant (the portion enclosed by solid lines) that

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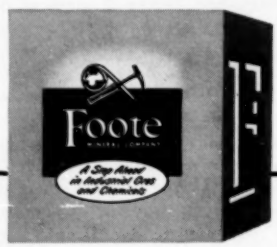

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FOR MORE INFORMATION CIRCLE 13 ON PAGE 48

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These sheets give such information as characteristics on reflection, transmission, adherence, hardness, durability, water resistance and other data you want in the early stages of planning work.

Of course, as you progress into a project, you may want our engineering help, and it is gladly offered whatever the nature and size of the job. Our business is largely one of working out specific design problems and then providing the finest quality vacuum-deposit products to meet the needs. May we help you?

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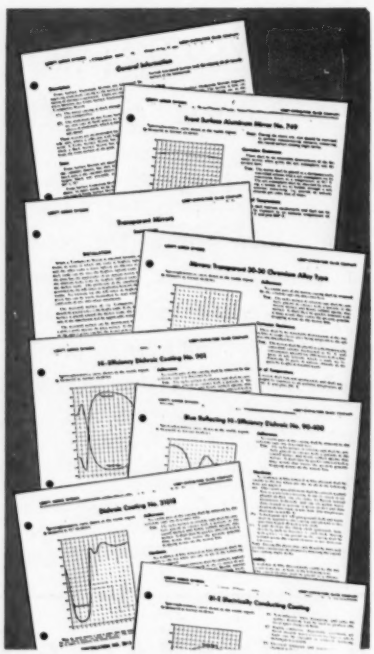

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FOR MORE INFORMATION CIRCLE 15 ON PAGE 48

should be traced in the literature (using names or structural formulae) to see if equally powerful or even better synergists can be found.

Thus there are eminently practical as well as academic reasons for developing the full chemical names of new substances. Granted, the public (and even most chemists) will find coined names (penicillin, sesamolin) or abbreviations (DDT, ACTH) or trade names (Serpasil, Santomerse) more convenient. But to the R & D chemist, the full names of chemical compounds are the essential key to the treasures that may lie hidden in their structure. (Adapted from the *Industrial Bulletin* of Arthur D. Little, Inc., Number 329, March, 1956.)

The Genius of the "Uncommon Man"

Behind every advance of the human race is a germ of creation growing in the mind of some lone individual whose dreams waken him in the night while others lie contentedly asleep. This was the contention of Crawford H. Greenewalt, president of Du Pont, in a speech before a recent meeting of the American Newspaper Publishers Association.

Greenewalt went on to say that the emphasis upon group effort in modern industry presents the serious problem of how to preserve the creative genius of the "uncommon man". It is a problem for management, for public education, for government, for the church, and for the press. And unless we can guarantee the encouragement and fruitfulness of the uncommon man, the future will lose for all men its virtue, its brightness and its promise.

Over the past 50 years, Greenewalt said, there has been a gradual, natural replacement of the individual by the group in the inevitable development of the nation's economy. The change over the years from the responsible individual to the responsible group has greatly increased emphasis on continuity of an enterprise. Greenewalt views with satisfaction, rather than alarm, the fact that as business enterprises grow because modern society leans so heavily on technology and many large units, the demand will be for increasing rather than decreasing aggregations of talent, manpower and resources. "The pressures of society," he said, "will inevitably produce their own controls and stabilizers. These pressures are great indeed . . . strength much more potent and compelling than the law".

"If I were asked what are the most important personal characteristics to make an engineer's life as happy as possible, I would, without hesitation, reply, 'A sense of humour and a sense of proportion'. A sense of humour is, indeed, indispensable to all engineers, and makes life easier in every way. As regards the sense of proportion, we have no doubt all heard about the professor who said 'There is no need to worry unduly; after all the earth is only one of the minor planets'. When one reflects that the sun itself is only one of many thousands of millions of stars in our Galaxy and that the Galaxy itself is only one of about one hundred million others known to astronomers, the tendency to over-exaggerate the importance of a particular development in mechanical engineering may be suitably influenced."

P. L. Jones, President,
The Institution of Mechanical Engineers
from the Presidential Address delivered at the General Meeting of the Institution in London on October 21, 1955.

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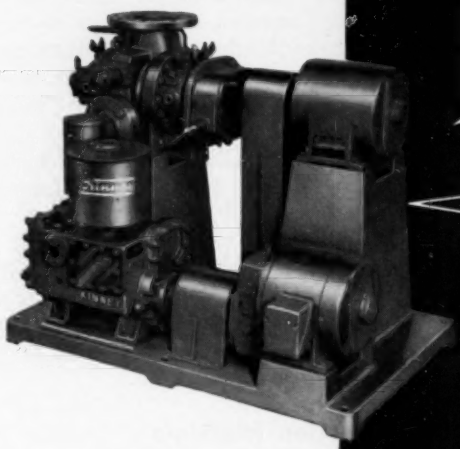

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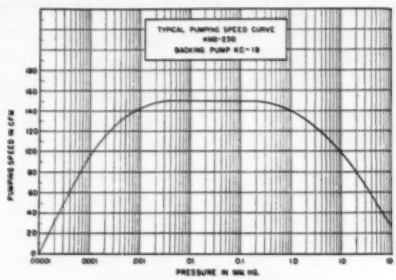
With your particular processing system in mind, investigate the outstanding performance records of these Kinney pumps. We will be glad to provide you with any vacuum data you need . . . to make your operation more economical. Request this data from any of our competently staffed district offices . . . in Baltimore, Charleston, W. Va., Charlotte, Chicago (La Grange), Cleveland, Detroit, Houston, Los Angeles, New Orleans, New York, Philadelphia, Pittsburgh, San Francisco, St. Louis, or The International Sales Office, 90 West St., New York 6, N. Y. Take time to make one of your smartest moves and mail coupon today for additional information. Kinney Mfg. Div., Boston 30, Mass.



SPECIFICATION DATA

Model **KMB-230** Two Stage Mechanical Booster Vacuum Pump

Ultimate Pressure (McLeod Gauge)	0.1 Micron
Free Air Displacement	230 CFM
RPM	3600/640
Motor H.P.	2 and 1
Oil Capacity	5 Pints
Cooling	Water
Shaft Seal	Mechanical
Shaft Diameter	¾/¾
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FOR MORE INFORMATION CIRCLE 16 ON PAGE 48

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Above all there's *opportunity*. As the chap who hired me put it, "This is the spot for men who are either stymied in a little company, or buried in a giant." More than twenty fields of employment are open—as shown by the list to the right.

I started with a detailed letter of inquiry to Howard L. Foote, at the address below. Why don't you do the same?

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SERENDIPICS

Love That Quinoa

The old French engraving "La Botanique" on the front cover of a recent issue of *The Laboratory*, published by Fisher Scientific Co., Pittsburgh, Pa. depicted the 18th Century search for new foodstuffs. The cover prompted a reader in Peru to report that an ancient crop has just been re-discovered in the high sierra region of that country.

Called "quinoa" and a staple since earliest Peruvian times, it has been assayed by chemists as very high in digestible proteins, vitamins, starch, other nutrients. And it has more calories than condensed milk, eggs, fresh fruit, or any vegetable you can name. Only drawback: a taste exactly like soap!

So Peruvian laboratories, under the encouragement of the United Nations' Food & Agricultural Organization, went to work and converted the stuff into an attractive, palatable form "not unlike American corn flakes".

Well, now that the laboratory men have done all they can do, the next step is, alas, pretty predictable: a phone call to a high-powered Yankee advertising agency, a name like "Happy Andes (The Incas Cried For It)", and just watch those cash registers sing.

Mass-Production Martinis

Here's a valve that never had it so good—a unique "cocktail valve" coupled with a tube arrangement to pour just the right amount of a Manhattan or a Martini mix into a cocktail glass. The dispenser, demonstrated by the Ross Operating Valve Company at the recent Chicago show of the ASTE, includes a mahogany base, the stainless steel tops of two coffee makers, a red button to push for Manhattans and a pale green button to produce Martinis. The valve used in the device is ordinarily employed for adapting air pressure to power such things as welding guns, air riveting and testing fixtures.

Unfortunately, you can't tell your troubles to this bartender.

Shave That Tiger!

Tiger whiskers, eagle feathers, kangaroo tail tendons and elephant hair are the unlikely subjects of a research project at the University of Michigan. These and similar materials are being studied by biophysicists in an effort to chart the structures of proteins, the complex compounds required in the life processes of all animals.

Why study such exotic materials when there are tons of robin feathers, cat whiskers and cow hair available? Because not all fibrous proteins are alike, the biophysicists want to find the ones with the best "orientation" (molecules located along the length of a fibre).

The researchers get their materials from a variety of sources, including museums and zoos. A Detroit radio commentator once aired their needs for the unusual items, and a woman promised some tiger whiskers if the source was not revealed. A man with an elephant's tail for a trophy sent hairs from it.

PUBLISHER'S NOTE: *The message on the opposite page is a paid advertisement of the Perkin-Elmer Corporation, Norwalk, Conn.*

For more information circle 18 on page 48.

G. M. BASFORD CO. • CALL REPORT

Date: April 6, 1956 Place: Benzol Products

Client: The Perkin-Elmer Corporation, Norwalk, Connecticut

Purpose of trip: To obtain background material for ad on Model 21 Spectrophotometer

From: F. Messner To: P. Wilks, C. Miller, P. Slawter, C. Perrin, J. Craig

I interviewed Dr. Stanley K. Freeman, Chief Chemist, Benzol Products Company, 237 South St., Newark, N. J. Benzol Products has a Perkin-Elmer Model 21 which they have had since September 1953.

Dr. Freeman said, "Because of the size company that we are, we use the instrument for just about everything: in quality control, in identifying products after reactions, to detect small amounts of impurities which could not be checked in any other way, to check customer samples, to check final material, in research work for determining molecular structure." He said the instrument is in use for about 4 hours each day, and would be used for longer periods of time if Benzol Products had more manhours available.

Dr. Freeman stated that he is "completely sold" on the P-E Model 21. He thought that the work which he has done on Allethrin using the Model 21 shows off the instrument to good advantage. The synthesis which Benzol Products uses is a fairly complicated 15-step process. Benzol Products must run various analyses at different steps in the process. Some of these analyses could not be done any other way, except via infrared; others could be done by conventional analysis but would take hours longer to do.

Dr. Freeman has also done research on the finished product, allethrin, comparing its stability with that of pyrethrin -- again using infrared. He said that the work on allethrin alone made the investment in the instrument worthwhile. Dr. Freeman said: "Just the mere fact that we could make allethrin and compete -- with the help of the instrument -- is interesting." (Attached to C. Perrin's copy of this report are reprints of technical papers by Dr. Freeman on this work.)

When Dr. Freeman first proposed purchase of the Model 21 he had to overcome some management resistance to spending $13,000 for an instrument which it was felt might be "something that only a big company could use." (There are probably a lot of good prospects for Perkin-Elmer Model 21's among small and medium-sized chemical companies whose management may have the same notion -- a misconception our ads should try to correct.)

Dr. Freeman said: "In my opinion, a small firm gets <u>more</u> use out of an infrared spectrometer than a large company. The small company will use it for nearly everything. They will learn more about how to use it. They don't have the time or manpower to handle the burden of analytical work which comes their way without an infrared spectrometer." He said that although you might be able to "get along" without one, once you have had an infrared spectrometer for a year, take it away and you would be hard put to continue to turn out as much work and such high quality work.

Dr. Freeman reported that the instrument required only one service visit in 2-1/2 years. That call involved only a minor adjustment which cost Benzol Products $15. Aside from this one adjustment he has had no trouble with the instrument. He said when he has a problem, he just calls Perkin-Elmer and they are always very helpful in clarifying things. (Note to P-E engineers: for publication work, the spectro-

Research and Development

Report on National Industrial Research Conference

Stepped-up research and development has been the major key to sales and profits for many companies in the last five to ten years. With "Research for Profit" as its theme, the first annual National Industrial Research Conference, sponsored by the Armour Research Foundation of Illinois Institute of Technology, took a long hard look at three important aspects of industrial R & D: research budgets, research management's decisions, and research results. Here's a review of highlights of the two-day meeting.

Utopia is not just around the corner. But barring an international catastrophe with results no man can foresee, the American economy will continue a long and sustained climb with no insurmountable barriers in sight. If any one factor can be said to be responsible for this happy state of affairs, it is what has been aptly called "The Mighty Force of Research".

The extent of R & D funds that will be pumped into the American economy by 1975 can only be surmised. Our economic seers are cautious, but it seems likely to be double or triple the $5 million spent for R & D by all bodies in 1955. One thing is certain: The role of R & D in company affairs will be magnified greatly; organizationally, the R & D unit will become the focus around which all other corporate activity revolves.

From the profit standpoint, the companies that waded in early, set up their laboratories, and manned them with a full corps of scientists and engineers are just beginning to realize the true relationship of R & D to their overall profit objectives. Beyond a doubt, the next 15 to 20 years will see harvest after harvest ripening from the seeds which have been sown in the recent past or will be sown in the future.

Radio Corporation of America is a good example of R & D coming home to roost in the rosy figures of the annual report. Today, fully 80 percent of its business comes from products and services which were not on the market at all ten years ago. Most electronics firms are confident that this process will repeat itself in another 10 years. The people in chemicals feel the same way; the solar and nuclear energy fields have not even begun to flex their muscles.

The most significant thing is that the nucleus for tomorrow's prosperity, translated into more and better jobs, new and improved products and services, and a higher standard of living for everybody, lies in the research and development laboratory *today*.

Research and Development: The Prime Catalyst

Dr. Haldon A. Leedy, head of Armour Research Foundation and a luncheon speaker at the conference, cited a recent study of R & D expenditures in 11 industries which shows that those industries which spend the most for R & D also have the greatest profit. Conversely, those which spent the

for PROFIT:

least, also gained the least.

The study pointed out that the top three industries which allocated 5.7 percent of sales for R & D had a 52 percent gain in profits. The middle three industries spent 0.9 percent on R & D and had a 9 percent gain in profits. The lowest three industries spent 0.2 percent and saw their profits shrink 3 percent.

In addition to helping companies reap greater profits, Dr. Leedy said, emphasis on R & D also helps many firms to steer clear of obsolescence and outdistance competition. Coupled with our system of free enterprise and the recent high interest in the art of good business management, the rise of organized R & D seems to be the prime catalyst in the U.S.'s fantastic rate of economic growth.

Scientific Output and Productivity

According to the ARF head, America's new frontiers today are the undiscovered basic laws of science and the potential applications of these laws. To capitalize on these scientific resources, the big question facing R & D now is whether or not it can continue to increase its output.

If R & D is to keep pace with the burgeoning productivity of the U.S., it must insist on efficient operations. Leedy feels that the shortage of technical manpower is this country's greatest obstacle to increased research output in the immediate future. But he pointed out that in spite of this shortage, research output can be boosted by increasing the efficiency of our research programs.

Leedy recommended the following operating methods and techniques which could contribute to more productive R & D operations:

- Acquisition and retention of the best creative minds available
- A well-planned program for the training and professional development of the entire research staff
- Selection of the best combination of staff talent to work on each project
- Provision of adequate tools for the scientist and engineer in the form of good equipment
- Availability to the scientist and engineer of various types of non-technical services so that he can devote his full time to utilizing his own specialized talent
- Allow the researcher utmost freedom in the area of scientific thought, but insist that he adhere to certain general policies the same as any other member of the organization
- Provide comfortable, well-maintained, but not necessarily expensive laboratories for researchers.

Leedy feels that the nation's critical shortage of technical manpower "may be a blessing in disguise", if it forces industry, the government, and the independent research organizations to take a critical look at the efficiency of their R & D operations. The average per capita output in the U.S. is three-and-one-half times the average for the rest of the world largely because of our efficient production methods. Leedy claims there is no reason why this same efficiency cannot be carried over to the research laboratory.

DR. HALDON A. LEEDY

I. Research Budgets

An Investor Looks at R & D Budgets

WINTHROP H. SMITH

By any standard, research is big business today. One reason why is that wise investors prefer to put their funds with the research-based company, where they know that one dollar can often be made to do the work of two or three. Winthrop H. Smith of Merrill Lynch, Pierce, Fenner & Beane emphasized this when he said, "Industrial research is most important to the investor today. He looks for it to develop new markets for old products, new products for old markets, improved products for all markets, and better techniques to help reduce costs".

The typical investor of the twenties was apparently often willing to buy a symbol and a price on the ticker tape, said Smith. In those days there were no capital gains taxes and other taxes were relatively insignificant. So the investor of yesteryear looked primarily for securities which would provide him with large profits over a relatively short time.

However, this species (the speculator) is far outnumbered today by the investor who looks for growing earning power, higher dividends and moderate appreciation of his investment over a longer period of time. He is more likely to place value on the efforts companies make to perpetuate themselves and research they undertake to generate further growth. Over the years, the security owner has come to recognize the immense contribution which R & D can make to the well-being of a company and thus to the value of his investment.

How Research Results in Profits

Smith cited several examples of how research has helped a company to greater profits and made it more attractive in the eyes of investors. According to Crawford H. Greenewalt, president of duPont, "Our growth has been overwhelmingly the result of internal development through research". About 27 percent of 1955 sales resulted from additions to duPont product lines in the postwar period.

Even the development of a single product in the research laboratory can exert a profound effect upon a corporation. Schering Corp. is a case in point. In February 1955, Schering introduced the anti-arthritic drug called meticorten. Primarily because of the enthusiastic reception given meticorten, Schering's sales more than doubled in 1955 and earnings increased five-fold. Its stock climbed from 22 to 58.

In late 1948 the Polaroid Corp. introduced the first model of its Land camera. The spectacular success of this instrument caused Polaroid's sales to increase more than 15 times and losses have been converted to profits.

Survey on R & D Expenditures

To cast some light on the current research activities of industry, Merrill Lynch recently completed a survey of almost four hundred corporations. Each was asked: (1) "In the 1955 fiscal year, how much did you spend for research and development excluding government-sponsored contracts and including government-sponsored contracts?" and (2) "What percentage of sales did each of these figures represent?" Because of long-standing policy, some of the corporations polled would not supply these figures even on a confidential basis. Others were unable to do so because of the classified nature of some of their government contracts. A few said they had no idea what they spend on research. But the results were generally satisfactory.

The question of semantics became involved in the compilation of results, since no two companies are likely to define R & D in the same terms or to report figures on the same basis. To compensate for these variations and to protect the identity of those corporations which provided data on a confidential basis, the results are presented by industry groups (see table below).

As might be expected, the aircraft figures indicate that this industry is a leader in research—both from the standpoint of total research expenditures and from the standpoint of research as a percent of sales. All companies answering the survey held some government contracts and about 75 percent of the research done by these firms was financed by the government.

CORPORATE EXPENDITURES FOR RESEARCH AND DEVELOPMENT—1955*

	Number Companies Reporting	Sales (Millions of Dollars)	Research Expenditures	Research As a % of Sales	% Research Government Financed
FARM MACHINERY	3	$1,791	$49.3	2.7%	Negligible
AIRCRAFT AND PARTS	12	2,779	142.8	5.1%	75%
CAR ACCESSORIES	14	2,520	27.4	1.1%	10%
BUILDING SUPPLIES	8	1,319	15.2	1.2%	5%
CHEMICAL	14	5,463	179.8	3.3%	Negligible
DRUGS—ETHICAL	8	704	33.2	4.7%	Negligible
DRUGS—PROPRIETARY	4	361	11.7	3.2%	Negligible
ELECTRICAL EQUIPM'T	13	2,448	168.5	6.9%	40%
FOOD	14	6,228	30.1	0.5%	10%
HOUSEHOLD EQUIPMENT	5	287	5.6	2.0%	Negligible
MACHINERY	6	674	21.1	3.1%	40%
MOVIE PRODUCERS	3	230	1.8	0.8%	Negligible
OFFICE EQUIPMENT	5	1,060	28.6	2.7%	Negligible
PETROLEUM	13	17,724	130.3	0.7%	Negligible
RADIO—TELEVISION	5	920	58.8	6.4%	55%
RAILROAD EQUIPMENT	7	975	24.6	2.5%	45%
TOBACCO	5	1,734	3.1	0.2%	Negligible
TRANSPORTATION	7	1,706	4.2	0.2%	Negligible
OTHER M'F'G	32	7,118	96.5	1.4%	Negligible
TOTAL	178	$56,041	$1,032.6	1.9%	20%

*Source: Merrill Lynch, Pierce, Fenner & Beane

The figures for the chemical and drug industries also show heavy emphasis on research. R & D expenditures as a percent of sales did not vary greatly from company to company in either of these industries. However, two chemical companies, neither among the largest in the industry, reported research exceeded four percent of sales; two drug firms reported research was over six percent of sales.

The statistics for the electrical equipment industry do not include General Electric which has, however, reported that its R & D costs in 1955 were well above the estimated electrical manufacturers' industry average of six percent of sales. The Merrill Lynch figures do include Westinghouse Electric, which dominates the sampling. Westinghouse sales account for slightly more than 50 percent of the group total and its research expenditures for almost 80 percent of the total. Thus while the statistics are by no means complete, they do reflect the importance which this industry attributes to research.

As for the total figures, research expenditures of all the companies answering the survey represented 1.9 percent of sales. This is very close to other estimates. According to this survey, 80 percent of research expenditures were financed by the companies themselves, and 20 percent by the government.

A Research "Coefficient"

Smith explained how some companies have attempted to establish a factor or coefficient by which their current research expenditures could be multiplied to arrive at the sales, or better yet, the profits of the company, at some future date. Minnesota Mining has calculated that every dollar spent on research eventually yields 25 dollars in sales. Put another way, Monsanto Chemical has found that for every dollar spent on research it must eventually spend six dollars on capital expenditures to make the products its researchers have discovered or improved.

At best, Smith said, the statistical correlation between research and capital expenditures, sales or profits, is tenuous in most cases. The host of economic and political factors which affect sales and earnings militate against a simple statistical approach to this problem. Even so, figures on research spending measure the quantity but not the quality of work done. And of course, not every research project undertaken proves successful.

From the Stockholder's Viewpoint

ROLAND P. SOULE

As R & D managers occupy more important niches in the corporate structure, they must not only be able to decide if a project is technically feasible, but also whether successful completion will contribute to the economic health of the company. In a talk before the conference, Roland P. Soule, vice president of Irving Trust Co., gave some of the rules for judging economic worth in terms of stock market performance—coupled with a warning that we may be spending *too much* on R & D.

Many managements, Soule said, undoubtedly used R & D too sparingly. But there are some who have used it too lavishly or too unwisely. More than a few companies have continuously spent large sums for R & D without corresponding benefit to their stockholders. And the number of such case histories may multiply in the future. Expenditures by industry for research and development have been growing much faster than our economy as a whole. Will R & D in these gargantuan doses help or harm the stockholder?

The risk lies in the huge new investments which must continuously be made in new machinery and equipment to give economic life to the facts learned in the laboratory and pilot plant. Each new investment carries with it not only the hope of something to be won but also the threat of something to be lost. If the result is to be good, then a number of basic economic principles must at all times be borne in mind. These principles relate, for example, to the screening of new projects, the means selected to finance them, the choice of capital structures, the percentage of earnings to be distributed as dividends, the types of business to acquire or liquidate, and certain other broad questions of company policy.

Measurement of Successful R & D

Nobody expects every successful engineering project undertaken by a company to increase its profits. For example, new models of automobiles, refrigerators and domestic appliances of all sorts need to be brought out at regular intervals. This can be a very expensive operation; huge new investments in tools and dies may have to be made each year. Of course, the hope is always held that the new model will outrun the competition and that a bigger share of the business will be obtained. But the project can still be considered successful if its only result is to keep profits at the same level as in the past.

Soule does not regard the periodic development of new models of established products as an activity which can be properly classified as "research and development". He concedes that the two activities may overlap in many instances, but that a fundamental difference in principle exists. Thus, the engineering of new models is mandatory if a company is to manufacture the product at all. It is almost as much a part of the company's day-to-day cost of operations as materials and direct labor. Presumably, the only alternative to engineering of this nature would be to go out of the business completely.

Two Types of Research

Soule went on to discuss R & D of the type to which an alternative course of action might be reasonably considered. The most obvious example of such activity is, of course, that which is designed to increase a company's earnings above the already existing level—the so-called *aggressive or expansion-minded* type of R & D. This consists characteristically of the development of new markets for existing products (in either their present or modified form) and the addition of entirely new products to the line. A company is under no immediate compulsion to undertake technical development of this type in order to stay in business. In this application of research, therefore, it is entirely in order to inquire if the results are worth what they cost.

But what about R & D designed to reduce the cost and improve the quality of a company's already existing products? Work of this sort, Soule claims, is always a major activity of industrial research organizations and often receives more attention than the development of new products. How can such R & D be classified? At one extreme its objective is to increase profits—which would classify it with the aggressive type of research. At the other extreme its objective is simply to keep the company in business—which would classify it with the engineering of new models. But between these two extremes the most common objective of the cost-reducing, quality-improving type of development is to combat long-term trends of an adverse nature. Thus it is not concerned so much with year-to-year changes in design as it is with the problems growing out of saturation of markets, shifts in consumers' buying habits, and technological obsolescence in general. R & D of this broad type may be classified as *defensive or protection-minded*. Since its goal is to prevent or to defer the loss of profits, it can be financially very successful even though it results in no increase in earnings.

Experienced and rational business managements see no reason, however, to appraise defensive R & D any less objectively than aggressive R & D. Just as the new earnings

added by aggressive action must be enough to justify their cost, so must the old earnings saved by defensive R & D be enough also to justify their cost. The basic principle is the same in each case, even though the visible effect upon reported earnings may be quite different.

It is not in terms solely of the magnitude of earnings, however, that the financial advantages of R & D—whether aggressive or defensive—can best be measured. The *"quality"* of earnings can be fully as important as their magnitude, as witnessed by the widely differing values given in the stock market to earnings of equal magnitude from various sources. Hence, it is in the market action of their stock that the shareholders of a publicly-owned company primarily feel the results of R & D.

R & D Accelerating too Fast?

Soule concluded his talk by saying that the optimum rate of growth of a company can be no faster than human minds, all down the line, can find successful solutions to these multiplying problems. "That is why," he said, "I have some misgivings about our accelerating rate of R & D expenditures. On the one hand, we see company after company committing itself to the goal of an ever-increasing corporate size. But, on the other hand, we also see an increasing difficulty in finding the necessary manpower. Thus, we are so short today of technologists of all descriptions that we are glad to hire almost any engineer, physicist or chemist we can find, and put him to work in the R & D laboratory. I do not predict that these developments will result in failure and that increasing corporate size will no longer be accompanied by increasing profits. I do fear, however, that corporate standards of performance may necessarily deteriorate and that the common stockholder may no longer gain from this expansion effort the same degree of benefit he has enjoyed in the past".

The Researcher and the Profit Motive

WM. E. HANFORD

Dr. William E. Hanford, vice president of R & D for M. W. Kellogg Co., discussed the many problems which face the modern industrial researcher. In his talk he divided people into two categories—the "doers" and the "workers". Since the "doers" are the people who create, the researcher belongs in this category along with the rest of the team that is driven by the profit motive.

Hanford further divided the "doers" into two categories —those who work in the present and those who work in the future. The "doers" who work in the present are Management, Production and Sales. The "doers" who work in the future are the researchers.

When the Management, Sales and Production "doers" make a good profit, or see the possibility of the loss of business to others, they call in their special industrial insurance agent—the Industrial Researcher. He is asked to cure their ills and to give them not only everlasting life but also everlasting high profits. For the researcher to produce these results he must have guidance from Management and Sales as to the type of products or service in which the company is interested, products or service for which the Sales Department feels they can develop a market. Without this guidance on the part of Management or Sales, no industrial research can be profitable.

With the company's objective before him the researcher must sit down and try to forecast several things, such as:

- What type of products or service are more likely to satisfy the demands of the Sales Department?
- Can I develop these products in time to meet sales requirements?
- Is the Sales Department outlook too short, and is it likely that the products they want will have an entirely different set of properties by the time I can get them developed?
- Are the raw materials available for the manufacture of the products they say will fill the bill?
- How far back must I go in the manufacturing sequence to get the desired raw materials and make the process economical?
- What will be the scale on which this product will be manufactured?
- Should the processes to be used for this work follow conventional lines or should I try to combine a number of steps and shorten the whole operation?

Forecasting Problems

Hanford says that the researcher's forecasting problems follow the same pattern as the sales forecast. The smaller the change required of research the greater the accuracy of the forecast. The smaller the item, the greater the ease of evaluating the market before the research gets into the expensive stages of pilot plant operation. If the market can be evaluated with a few hundred pounds, the problem is much simpler than if it requires twenty tons. The nearer the process is to an existing operation the easier it is to make either of these products regardless of size because, in general, simple modifications of existing equipment will do the trick. For the researcher the forecast not only gives him guidance but it selects and sets the route he must follow, and in many cases he cannot change the course until the research program is completed.

The Competitive Side of Research

There is another phase to the problem, said Hanford. Just as business is competitive, so is research; if the researcher selects the wrong objective one of his competitors may beat him to the solution with the same product, or even a better one. No one realizes better than the industrial researcher the competitiveness of modern business for on this side of the business there are no part scores or second prizes; it is a "winner-take-all" game. The researcher must make a forecast as to the saleability of his idea with fewer facts than the Sales Department.

In research it is generally conceded that it takes from five to seven years to get a product from the first successful laboratory experiment into commercial production. In this time-table Hanford starts with the *first* successful laboratory experiment and not with the beginning of the project. It may take anywhere from one week to several years to get that first successful experiment. Before research is commercially successful many people have contributed to the effort. Is it any wonder that in the years from the conception of the idea to reality, the researcher and his contribution is often forgotten in the enthusiasm to bring home a winner?

In sum, Hanford says that research takes time and the longer it takes the more difficult it is to say who and what made the profit.

Report from Defense

Clifford C. Furnas, Assistant Secretary of Defense (Research and Development) discussed the expanding state of Soviet technology and the threat that this poses to our national security and way of life. Considering world conditions, he feels that our course of action in R & D becomes quite clear. In addition to the effort required to maintain our forces in a continual state of readiness, we must expend substantial R & D effort to insure that our fighting forces in future years will have the best possible weapons.

Furnas said that an extremely difficult problem in the management of the Defense Department is the determination of how much money should be devoted to R & D each year. In the Department the identifiable R & D appropriations requested for next year are about four percent of the Defense budget. According to Furnas, the Department wants to support a program which will maintain a technological margin over our potential enemies and which will allow the exploitation of scientific advances for weaponry. At the same time the Department does not want to spend more than can be used effectively as this might well inflate costs and will produce no greater results.

CLIFFORD C. FURNAS

On the other side of the coin is the necessity for maintaining an expanding civilian economy. This brings into consideration the nation's total capacity for R & D. On the Defense side there are other government agencies besides the Defense Department that are doing R & D work. A considerable portion of the Atomic Energy Commission program of some $400 million and the National Advisory Committee for Aeronautics program of some $70 million must be classified as military-related work.

Other Determining Factors

Other factors enter into determination of the level of the military program, Furnas said. Most important of these is that the military R & D appropriations do not cover all of the funds which support the Defense Department's R & D effort. It has military personnel working on projects and tests who are paid from a separate appropriation; it receives money from the Construction Appropriations for the capital construction of laboratories and test facilities; and it receives substantial support from the Procurement and Production Appropriation for funds to buy prototypes for engineering and service tests and for the construction of facilities at contractors' plants.

Just as in industry in recent years, Furnas said, Defense Department costs have gone up. According to the Bureau of Labor Statistics, R & D costs per scientist or engineer have increased about five percent per year. In addition, our weapons are becoming more and more complex. The number of engineering man-hours that now go into the development of a jet engine is close to double the number that went into the last piston engine. The development cost of the B-52 has been more than 2½ times that of the B-36; the development cost of the F102 was more than twice that of the F86.

II. R & D Management Decisions

Some Views on Basic Research

One of the most important research decisions top management and research management must share in making is the allocation of funds for fundamental and applied research. One big difficulty in reaching such a decision is that the line between fundamental and applied research is difficult to draw. Another is the lack of a generally agreed-upon definition of fundamental research, even within the confines of a company.

Most companies with research and development programs pay at least lip service to the importance of basic research, although many of them are content to wait until they can utilize somebody else's published findings. GE and Bell Labs are today the recognized frontrunners in basic research. The Langmuir's of GE and the Davisson's of Bell are proof that basic research can pay off handsomely. Yet the fact remains that many companies which should be undertaking basic research on a larger scale and as an outpost of future profitability are neglecting the job. While the estimated cost of all industrial research and development in the U.S. in 1953 amounted to about $3.7 billion, only about four percent or slightly under $150 million of this went for basic research.

Elisha Gray II, president of Whirlpool Seeger Corp., and another conference speaker, described "pure" research as that part of scientific exploration that seeks to push back the perimeter of man's knowledge, without having as a motivating factor any particular or known commercial application. Gray, in common with many another industrialist, thinks that the amount of money being spent for basic research in this country is pitifully inadequate. This paucity of industry support for basic research could be our Achilles' heel, said Gray.

ELISHA GRAY II

Why Pure Research is Necessary

He went on to state three reasons why, in his opinion, pure research is necessary:

- It provides the seed of scientific principles on which new, applied engineering must rest.
- Basic research will be essential to develop substitutes for our rapidly dwindling natural resources.
- We must keep pace in basic research for purposes of national defense.

Private industry, Gray declared, has neither created the proper environment for basic research, nor has it contributed significantly to its growth and development. The reasons are quite clear: In most circumstances, pure research cannot be predicted as a profit-making endeavor. By its very nature, therefore, pure research does not contain the elements which allow for exercise of the ordinary type of management decision.

Tax Exemptions for Pure Research

Gray went on to suggest that the government should encourage pure scientific research by granting industry tax exemptions for this purpose. Just as the government gives special tax consideration to the development of natural resources, it should likewise give special consideration to the development of scientific resources. Money spent for pure research should be deductible in whole or in substantial part from the federal income tax, he said.

In pursuing fundamental research Gray suggested that industry follow one of two courses: (1) isolate a pure research effort geographically as well as in the line of management (since it is difficult to create the state of mind most conducive to pure research in a commercial business atmosphere); (2) if the above is not practical for an industry, basic research should be entrusted to non-profit research organizations and universities. In such an academic atmosphere, research can thrive and produce its finest.

HERBERT J. BUETOW

Speaking on the same subject, Herbert P. Buetow, president and director of Minnesota Mining & Manufacturing Co., spelled out two compelling reasons why industry should spend money for fundamental research: (1) industrial leadership and (2) world position.

An industry that expects to maintain its present position —and improve on it in years to come—either is or should be investing part of its bottom-line (research) dollars in fundamental research, he said. "One might ask why a company should want to grow when the result of growth . . . continues to be paid out largely in taxes. The answer . . . is that we (3M) have built a strong organization of young capable people, and if they thought we were not going to expand—which is the only way for them to become more important in the scheme of things—we would soon lose this driving force which has kept us growing rapidly."

3M's Attitude Toward Basic Research

Buetow cited how the encouragement of basic research has helped 3M to grow over the past 25 years. Over this period the company maintained the attitude that a research man should not be regimented. If he so chooses, he should be able to regard part of his budgeted time as opportunity in which he is free to try out any idea which he thinks might lead to something the company can do.

As a result of this attitude—increasing fundamental knowledge in its own field—3M scientists came up with such profitable products as waterproof sandpaper, cellophane as a tape backing, glass-beaded reflective signs, colored quartz granules for roofing and magnetic recording tapes.

Buetow warned that a company should not "expect too much, too soon" from its R & D efforts. "We know from experience," he said, "that we can expect to wait about five years on the average before a new product returns half of its original investment".

Buetow cited eight large companies in the electrical equipment and chemical industries that are spending the lion's share of the basic research dollars; he suggested that the owners of American industry are willing to pay an even higher premium for ownership in such concerns. As of the end of March these companies showed a price-earnings ratio ranging from 20 to 37 percent against an overall 15.3 ratio for the Dow Jones industrial averages of 30 representative stocks.

Utilizing Outside Research Assistance

GEORGE C. ENSIGN

Properly used, the outside independent research organization has helped many a company to do a more efficient job. At the same time, by acting virtually as an "arm" of the company's research unit, it can enhance the general profit picture of the firm by contributing the technical "know-how" that frequently cannot be acquired in any other way.

According to George C. Ensign, director of research for Elgin National Watch Co., Elgin is a firm believer in outside research. "The organizations with which we work," said Ensign, "make available to us more millions of dollars worth of equipment and operators trained to use them, than we could dream of purchasing for use in our home laboratories. We have also learned that the consulting aspect of our relationship with these laboratories is invaluable. Literally hundreds of the best technical men are available to us through consultation."

Deciding When to Obtain Outside Services

When should the services of the outside research facility be sought? Ensign says it may be feasible if any of the following familiar situations prevail:

- I lack qualified men to attack a problem.
- We are short of space or equipment.
- We can't afford the capital investment required for the research.
- It's an old problem and we are completely out of ideas.
- I just don't know how to tackle it.
- It calls for a variety of scientific skills. We could never collect that much talent in our laboratory. And if we were to hire them, what would we do with them after the project has been completed?
- It seems ill-advised to expand our staff to take on this study. It looks like a temporary situation.

The Question of Costs

In considering the services of an outside organization, the matter of costs is bound to arise. Figures of $1200 to $1500 per month per research worker assigned to the project are good round figures to use. When dealing with a specific agency, this may be somewhat high or low, depending upon the sort of scientific talent needed for the study, the type and quantity of equipment required, the space needed, the amount of supplies, travel expense, power and various other items to be considered.

Selecting an Agency

The most important consideration in choosing an agency is its reputation and competence, Ensign said. Often, particular agencies are unusually strong in certain fields. Per-

sonnel of demonstrated ability, as well as the necessary facilities in the field of study, are extremely important.

Visit the laboratories, Ensign said, and form your own impression of their efficiency and competence to undertake the study. If possible meet with the man or men who could be assigned to your problem. You may also want to check with some of the older sponsors of work in the laboratory. Give considerable weight to the location of the facility. Close liaison between your home staff and the working group cannot be over-emphasized.

Elgin assigns the project to one man in the home laboratory. This man is neither the Vice President of something, nor is he the director of research. Rather he is the Research Engineer on the home staff best qualified to direct this project, and it becomes *his* project. By handling a project in this manner Elgin feels it gains several advantages. First, any opposition from the research staff is overcome in advance; they might otherwise entertain a feeling that the company lacks confidence in their ability. Second, the broadening experience gained by staff members in directing the work is invaluable. And third, it saves wear and tear on the director of research.

Budget and Control of Project Costs

How are project costs budgeted and controlled? According to Ensign, "You will find that there is no problem of cost control unless you create it. The laboratory will discuss with you in advance the rate of expenditure that they suggest. The final figure worked out becomes law the moment you authorize expenditures to start. I know of no instance in which an outside facility has deviated from the budget without prior approval from the sponsor. We have found it actually easier to control project costs of outside work than to control cost on our own projects."

Measurement of Research Results

SEMI J. BEGUN

According to Semi J. Begun, Director of Marketing for the Clevite Corp., the measurement of research results can be related to the type of organization which undertakes this kind of work. Four groups may be considered. First, the U. S. Government which through its laboratories and through sponsorship in other organizations promotes the research concept. The second group consists of the universities which have been for centuries protagonists of fundamental research. Third, there are a number of nonprofit and also profit-making institutions. The former do research work either under endowment or under contract, while the latter primarily do contract work. Finally, there are the research and development departments of manufacturing organizations in industry.

Government Research

Most of the government research efforts are aimed at building up the country's defense potential, said Begun. There is hardly any need to justify the necessity for these activities. Since research is not related to any form of commerce, only a qualitative scale can be used to measure its results.

Judgment is of considerable significance in relation to any government research activity. No nation, however wealthy, can afford to allocate all of its resources to the development, design, and the building of weapons and defensive devices. If the fullest value is to be obtained from research, therefore, the skill with which the nation, and for that matter any commercial organization, selects its research projects is vitally important and making the proper choice calls for excellent judgment.

University Research

The research done in universities is primarily of a fundamental nature. Since it is the ambition of any university to establish a prestige position for their faculty members engaged in research, one yardstick for measuring results is the degree of recognition given to their accomplishments by other professional men working in the same fields. Usually, the research efforts of a university are also closely associated with a desire to teach the student how to develop the best scientific approach. Hence, another measure of a university's research endeavors is the technical competence of the young scientists it graduates.

Research Institutions

In discussing research institutions, Begun excluded those research efforts which are sponsored by a government body or through public funds. The remaining activities are then likely to have the same objective as those of business concerns engaged in R & D for profit. However, the results of their work can frequently be measured by a somewhat different yardstick. Since the services of these institutions are similar to those rendered by other professionals such as accountants, attorneys, or physicians, the degree of their clients' satisfaction is a reasonable basis of evaluation. As for the fee paid, a business concern may subsequently relate this to its operations in the same way that it would relate funds for projects carried out by its own R & D activity.

Research in Industry

When considering research activities as an integral part of a business enterprise, Begun said, we now find ourselves in an area where quantitative yardsticks must be applied as they are to all other phases of the business. Research must be correlated, therefore, with business profits.

The expenditures for research will vary, depending upon the activity of a commercial organization. It is interesting to examine the R & D budgets of some organizations where such information has been made available. The average R & D expenditure for all manufacturing industries is believed to be between 2.0 and 2.5 percent of gross sales. General Electric reports that their 1955 R & D expenditures were over three times the average for manufacturing industries. This would indicate three to four percent of sales for research and development.

Bendix Aviation reported an estimated R & D expenditure in 1955 of about ten percent of sales or nearly five percent for research. International Business Machines reports they are currently spending about four percent of sales on research.

In discussing the results of a research group as an integral part of a commercial concern, Begun strongly emphasized one very essential point. Even the best conceived and executed research program is only one of the many factors contributing to the success of a business. The capability of the manufacturing organization, the quality of the marketing effort, and the ability of the company management to coordinate and direct all play a vital part in producing a

profit. Because of the interrelation between all of these functions, it becomes almost impossible to express the value of research by means of any simple formula.

Importance of Management Guidance

In Begun's opinion, the importance of obtaining proper guidance from company management ranks about highest on the list for making the services of a research group of real value. It is true, of course, that the R & D organization must be staffed with capable personnel and must possess all of the facilities required in this advanced technological age to perform its function successfully, but this alone is not enough. The company management must define the areas of work in terms of how well they may fit into the manufacturing and marketing organization of the company. When areas are defined which do not fit the existing manufacturing and marketing organizations, management must be prepared to furnish the necessary facilities for commercially exploiting the research accomplishments. In addition, management should be most careful to avoid sanctioning research work in fields which they do not wish to exploit commercially, nor should work be sponsored which the company lacks the financial resources to exploit. While these may appear to be rather obvious rules, nevertheless they are broken every day.

In performing the guidance function, company management must also consider the risk element basic in research. This element is present in any search for the unknown. A company should not place its bets on specific aspects of research since it must recognize that some of the projects will not turn out as well as was originally expected and that others will fail completely. Something that looks good in theory may fail through lack of a material with characteristics which are essential for success. Some device may work perfectly in the laboratory but may not work at all under conditions of commercial production.

Two Main Goals of Research

Begun said that the research activity of a concern in business for a profit has two main objectives, namely, to protect the competitive position of the organization in a world of technological progress and to be an instrument of planned corporate growth. In the first, efforts are directed primarily to improving existing products, customarily a gradual process in mass-produced articles. These days, no manufacturer in a competitive business can afford to be behind with regard to the performance characteristics of his products. Even with the most effective marketing efforts, ground will eventually be lost if these are not constantly improved. The effectiveness of R & D activities aimed at protecting the competitive position through improvements to existing products may, perhaps, be measured in two ways. First, by the degree to which dollar profit levels are maintained, and then, by the ratio of R & D costs to the total amount of profit.

III. Research Results

The Record of Profitable Research at Bell

Mervin J. Kelly, president of Bell Telephone Laboratories, traced the record of profitable research in his organization during one of the conference sessions. Considering the fact that Bell Labs is one of this country's most ardent devotees of "pure" research, Kelly's definition of research and development is illuminating: "Research and development is the operation through which the coupling of science and engineering provides the knowledge for the design of tools that enrich the lives of all men."

No one can argue that Bell Labs has not contributed a full measure to the general welfare and prosperity of the U. S. It performs research in the physical sciences in all areas that might be expected to provide new knowledge for communications technology. While telephony is the princi-

MERVIN J. KELLY

pal service provided, many others have been supplied in recent years including radio and television program distribution and record and data transmission. Since 1938 Bell Labs has also worked on research and development of communications and weapons systems for the military.

What do these research and development efforts mean in terms of Bell's vast consuming public and the company's profit picture? With regard to the first, telephony has become global. Today any one of the nation's 54 million telephone subscribers can reach not only every other subscriber, but also more than 93 percent of the 38 million telephones of the rest of the world. Other by-products of research include improvement in the quality and naturalness of the transmitted speech.

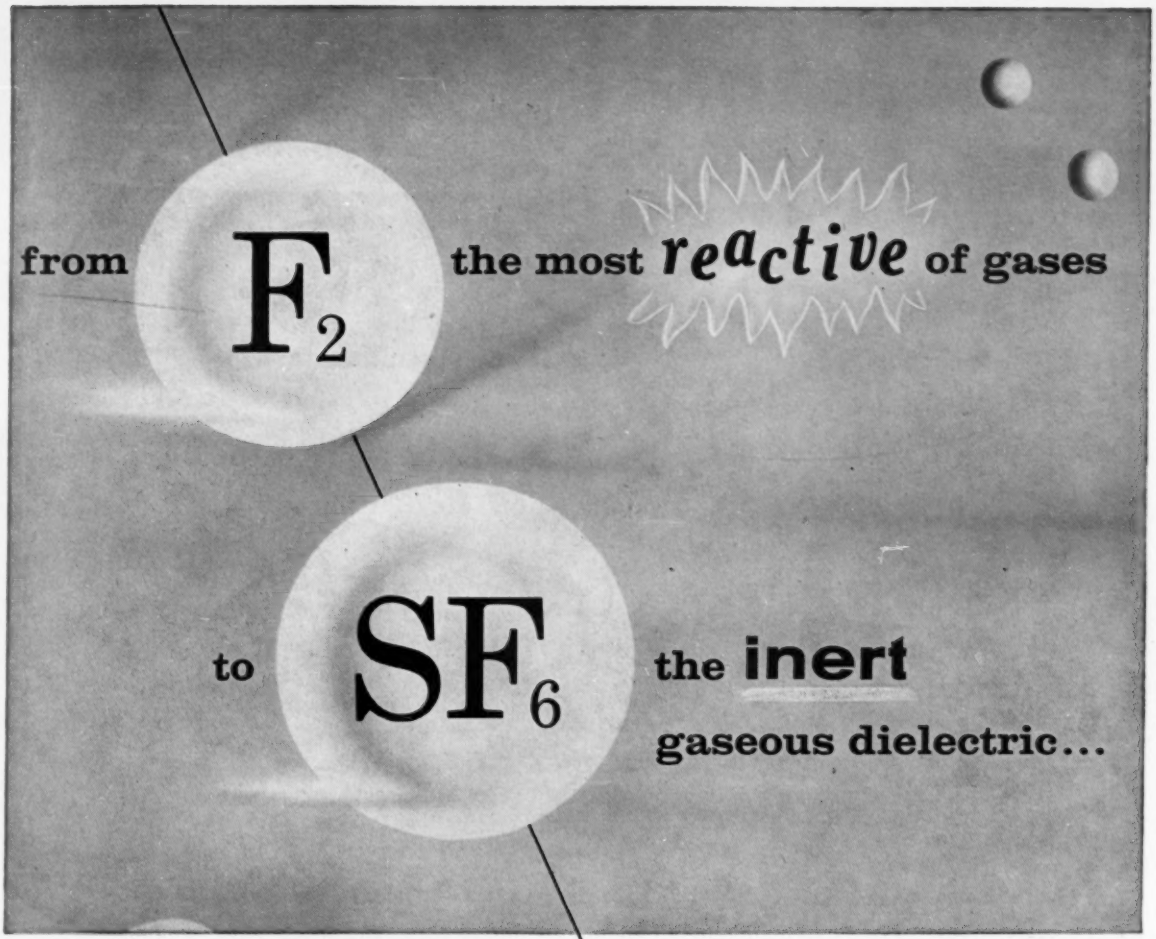
That the Bell Telephone System has profited mightily from these researches is known to even the most disinterested observer of the stock market. Kelly says that the sales volume of the electronics industry in 1955, only a half century after its birth, was some $11 billion. "Profitable research in many of the nation's laboratories, along with that of our own laboratories", he declared, "has created this huge industry".

Station Set Research

Kelly pointed out that station set research (research on the transmitting and receiving instrument) has been one of the most important areas of research for Bell. Station set research has helped to lower the cost of components and their assembly into the set and to improve them functionally as well. The economic gains from this research are well illustrated by the price history of these sets. The improved sets now in production cost less than the sets of 1938, even though materials and labor costs have risen some 80 percent. In the past 25 years Bell has poured $50 million into station set research, with impressive economic gains.

The Bell record of profitable research is truly amazing. Is the company satisfied with the record to date? According to Kelly, research in progress since the close of the war is opening up a completely new area of telephone technology. The new technology will result in major economies; present telephone service will enjoy a new cycle of lower costs.

Bell, of course, is one of the nation's outstanding examples of research applied to improve and expand service, lower costs, and enhance profits. But many hundreds of less well-known concerns in every field have applied the same research philosophies to their own operations with profitable results. END



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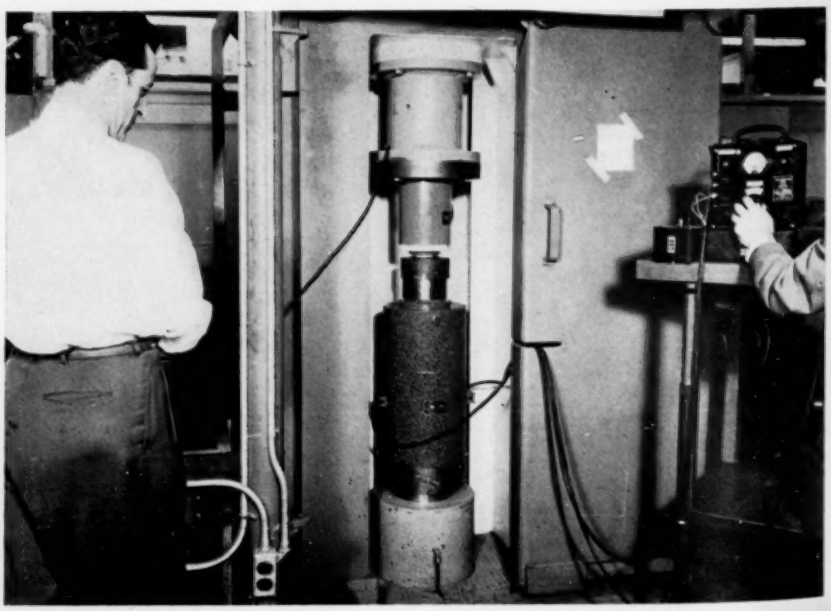
STRETCHING STRATEGIC QUARTZ BY SOUND SLICING

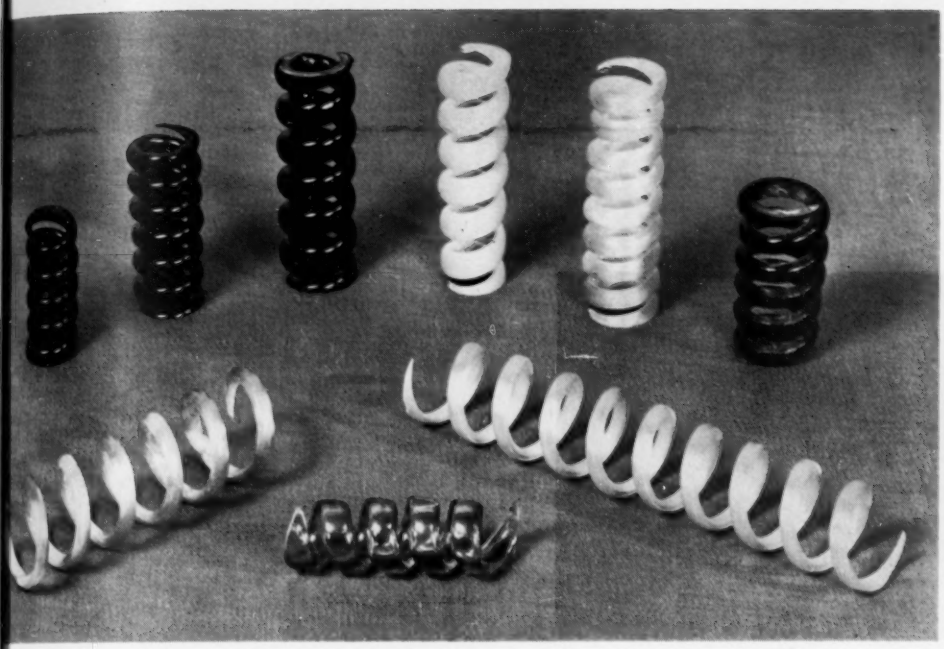
This technician is examining a quartz crystal from which 21 frequency-determining wafers are being cut at once by a Raytheon ultrasonic slicer. At right is a crystal partially cut by a conventional diamond saw. Since the "sound slicer" cuts 12mil wafers much closer together than the 33mil wafers sliced by the usual means, about three times as many wafers can be cut from a quartz crystal. Engineers at the Signal Corps' Fort Monmouth Engineering Lab developed the technique to stretch our supplies of strategic quartz, now mainly imported from Brazil. About 50 wafers are used in a handy-talkie, for example.

prototypes

ROCKET THRUST MEASURED BY GIANT TRANSDUCER

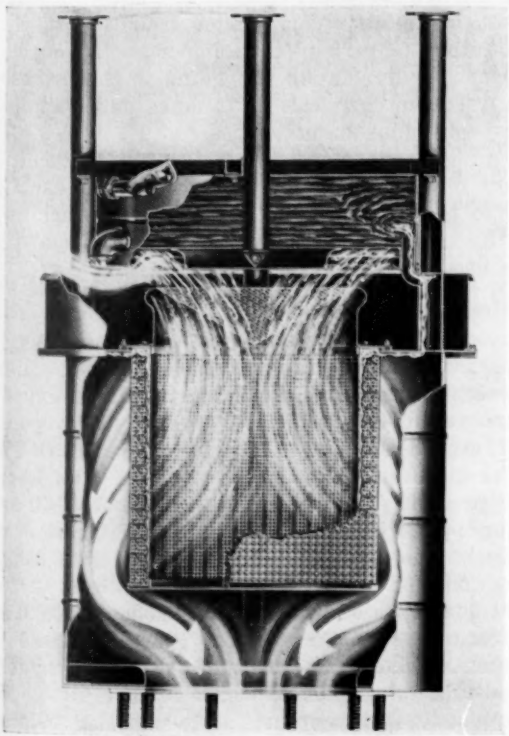
Most of the emphasis today is on miniaturization, but recently Baldwin-Lima-Hamilton engineers were called on to design their largest "SR-4" type load cell. To measure the thrust of a rocket engine, the transducer is being calibrated to take 250,000 lb in either compression or tension. A 200% overload can be applied without danger of mechanical failure. The transducer is 22" high with a 12" OD.





PLASTIC SPRINGS CAN BE MASS-PRODUCED

A practical process for making plastic springs in large numbers has been developed by the National Bureau of Standards. With a strength-to-weight ratio that is often better than that of metallic springs, these glass-fiber reinforced springs are nonmagnetic and have low electrical and thermal conductivity. Their high corrosion resistance should make them useful in chemical plants. The springs are molded by drawing resin-soaked glass fibers through vinyl copolymer tubing and wrapping the loaded tubing in a helix around a mandrel, as illustrated. After curing, the tubing is removed. They show an increase in recoverable energy due to "work hardening".



NO MOVING PARTS IN AIR FILTER

Low static pressure loss is achieved in this oil scrubbing air filter by reversing the conventional oil and air circuit. Air is drawn in under a weather hood set low on the unit and is directed through an air-flow regulator tube to an oil control pan. Here the air picks up droplets of oil which are carried up through a diffuser cone where oil and air are thoroughly mixed and air is scrubbed. The air then passes through the cylindrical filtration element where dirt particles and oil droplets are removed, permitting clean, oil-free air to flow to the engine, blower or compressor. No oil pump is required. Developed by the Air-Maze Corp., Cleveland, Ohio, the "LPD" filter is made in a variety of sizes.

Birth of a New Industry:

Gamma Radiation Processing Facilities

You hear more about atomic ships, planes and power houses than about irradiation of foods and chemicals, yet in the next few decades food preservation and chemical processing by powerful gamma sources are likely to become commonplace. If these sources are spent power reactor fuel elements, nuclear power could be reduced in cost. This important tie-in is explained here as a significant element in the design of irradiation facilities.

L. E. Brownell and J. V. Nehemias

Last summer Dr. Brownell spoke at the Geneva "Atoms-for-Peace" conference. Professor of Chemical Engineering at the University of Michigan, he has also been Supervisor of the Fission Products Laboratory there since '51. He designed bread-machinery for Baker Perkins, Inc., for a number of years. Assistant Supervisor and Health Physicist at the Laboratory since '51, Mr. Nehemias was associated with Brookhaven National Laboratory from '49 to '51. He is also a lecturer in Chemical and Metallurgical Engineering at the University.

Some earlier publications by other authors involved comparisons of the advantages and disadvantages of gamma radiation from radioisotopic sources with high-speed electrons from accelerator machines. Unfortunately these earlier studies were based on designs and arrangements of the gamma sources that resulted in unfavorable conditions for gamma sources when compared to machine accelerators. Gamma sources have certain advantages and certain disadvantages when compared to accelerator machines. The advantages cannot be properly realized unless the gamma radiation sources are properly designed so as to give efficient and uniform radiation doses throughout the product being irradiated either by batch or by continuous process.

Thirty years ago, when the family refrigerator first came into wide use, the eating habits of millions of Americans were virtually revolutionized and a new industry was created. Now we may be on the threshold of another startling revolution in food preservation. For with the coming of irradiation to delay food spoilage, meats and vegetables will keep for much longer periods under refrigeration and, when completely sterilized, without refrigeration. In addition, vitamin content will be enhanced.

This millennium in food preservation has not yet reached the practicable stage, for several reasons. For one thing, some radio sterilized foods presently taste, smell or look terrible. For another, a doubtful public must be educated to accept nuclear treatment of the food they eat. In addition, the present supply of radioactive materials is limited, although the future supply may be very great.

Notwithstanding these drawbacks, many products will doubtless be treated with gamma radiation in the foreseeable future. Of perhaps equal importance to our economy will be nuclear irradiation for aiding in the processing of presently known chemicals or to make new chemicals and plastics with unusual properties.

The design and manufacture of radiation facilities will become a multi-million dollar industry. As an early contribution to the new art of designing these facilities, this article discusses some design considerations and the cost factors used in selected gamma sources.

Possible Gamma Sources

Today only a limited quantity of gamma-emitting radioisotopes are available, such as cobalt-60 and cesium-137, which might be used for the commercial irradiation of chemicals and food. These radioisotopes are quite expensive at present, even when purchased in large quantities. The unit costs for large quantities range from a low of about two dollars per curie for low specific-activity cobalt-60 to about 10 dollars per curie for refined cesium-137. These prices are so high that processing with gamma radiation using such sources would be limited to a few applications.

Great quantities of waste fission products are stored by the Atomic Energy Commission. However, these wastes are stored as dilute solutions and are usually mixed with chemical-processing wastes, which further dilutes the fission products. It is impractical to consider using these

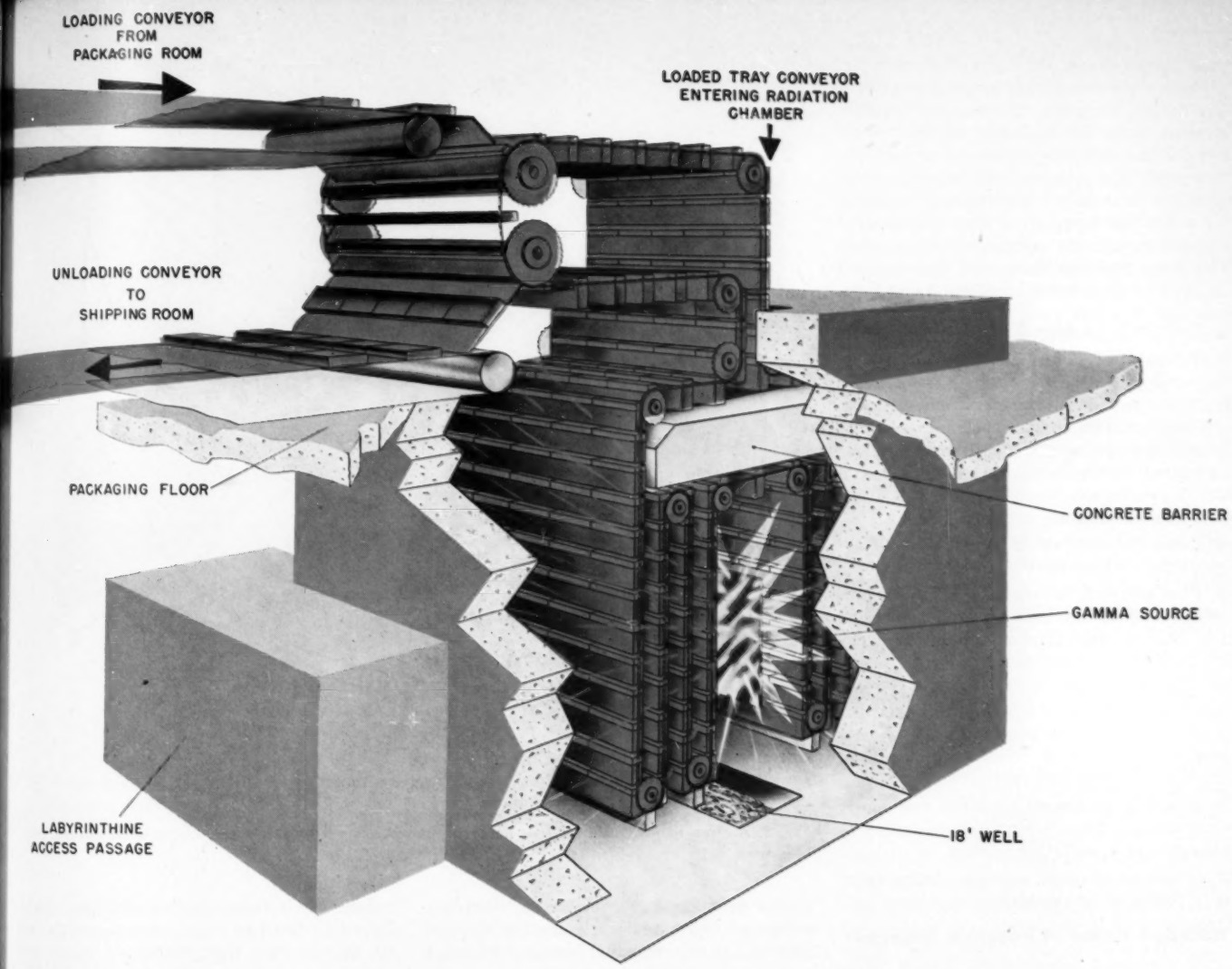


Fig. 1. Cutaway view of a gamma-radiation installation for processing prepackaged meat

materials until they are processed. Such processing would involve concentration and possible separation of the fission products and suitable packaging, probably in the anhydrous state. Such a processing plant would involve the expenditure of a number of "megabucks" and probably could not be justified until some irradiation pilot plants have been proven, using other sources of radiation. Eventually mass-refined cesium-137 should be available in the range of from 30 cents to one dollar per curie, and concentrated gross fission products containing cesium-137 at a lesser cost.

The only high-level gamma sources that will be available in large quantities in the near future at a reasonable cost are the cooling reactor fuel elements from the heterogeneous reactors and the reactor slugs from production reactors. Rental incomes from spent fuel elements might make it possible for nuclear power plants to compete economically with conventional plants and thus hasten the availability of economical atomic power. The consideration of income from the rental of spent fuel elements can be justified by our studies.

A current practice in chemical-processing plants for the treatment of spent reactor fuel elements and reactor slugs is storing the elements or slugs under water for several months before processing. During this time the intense radiation of the fuel elements is dissipated in the water used as a shield and usually is wasted, except when used in experiments. The costs of this storage period could be defrayed and a profit recovered by using the cooling elements or sources of radiation in commercial irradiation facilities. Cooling reactor fuel elements have a very high gamma activity but decay rapidly. To maintain the production of such a facility at an economic level of operation, the fuel elements would be replaced frequently.

Renting Spent Fuel Elements

In some of the earlier feasibility studies a rental charge of $250 per month was assumed for fuel elements. These studies show that such charges were feasible and in many cases the rental charge might be increased 100% or more without seriously increasing the unit cost for irradiation. Thus, the rental of cooling reactor fuel elements could provide a valuable by-product source of income which might be sufficient to render it possible for nuclear power to compete with power from fossil fuel. For example, a nuclear-power reactor might be able to maintain 400 fuel elements (cooling or spent) on rental during the year. A single food-irradiation facility might use 20 such elements: thus one power reactor might supply 20 such installations. If a rental charge of $250 per month per element were made, a by-product income in the range of $1,000,000 per

year might be realized for each reactor.

From the standpoint of by-product gamma irradiation, complete "burnup" of the fuel element would be desirable, as this would remove the inventory costs in a partially "burned" fuel element. If burnup were complete or nearly complete and breeding were not involved, processing of the fuel element might be completely eliminated. The spent fuel elements could then be used as sources of gamma irradiation until decay had reached such a point that they were no longer useful. At this point the fuel elements could be either put into storage or reprocessed to separate and concentrate the remaining radioactive wastes.

To summarize, in the years to come it is anticipated that there will be a number of competitive types of gamma source available for radiation processing and that these sources might be any of the following:

- Completely spent or nearly completely spent fuel elements.
- Fuel elements with partial burnup available between the time of removal from the reactor and processing for recovery of fissionable materials.
- Separated cesium-137 prepared from existing stored waste fission products or produced as a by-product from homogeneous reactors or from the processing of fuel elements and reactor slugs.
- Mixed gross fission products sufficiently concentrated from processing wastes to be valuable as a radiation source.
- Cobalt-60 or other suitable gamma emitters produced in production reactors.

Relative Value of Possible Sources

If processed concentrated fission products are used as a source of radiation, their cost might be determined in large part by the cost of concentrating and packaging. However, such information is not available because large quantities of the mixed fission products have not as yet been concentrated and a cost estimate for the processing, to be reliable, would require a rather thorough design of the process being considered. As there are many different types of fission-product wastes and many different types of processes that may be used in preparing these materials for industrial use, no direct approach to this cost estimate will be attempted. Another approach to the estimate of the value of mixed fission products might be made on the basis of the comparative value of such radioactive materials and cesium-137. Two-year-old fission products have gamma activity primarily from cesium-barium-137 and from cerium-praseodymium-144. The cerium-144 present in two-year-old mixed fission products has 7½ times the activity of cesium-137 but has a half-life of only 290 days as compared to 33 years for the cesium.

Fig. 2. A high-intensity irradiation source used for batch processing. The 50 cobalt rods arranged in two rows are jacketed in and supported by aluminum.

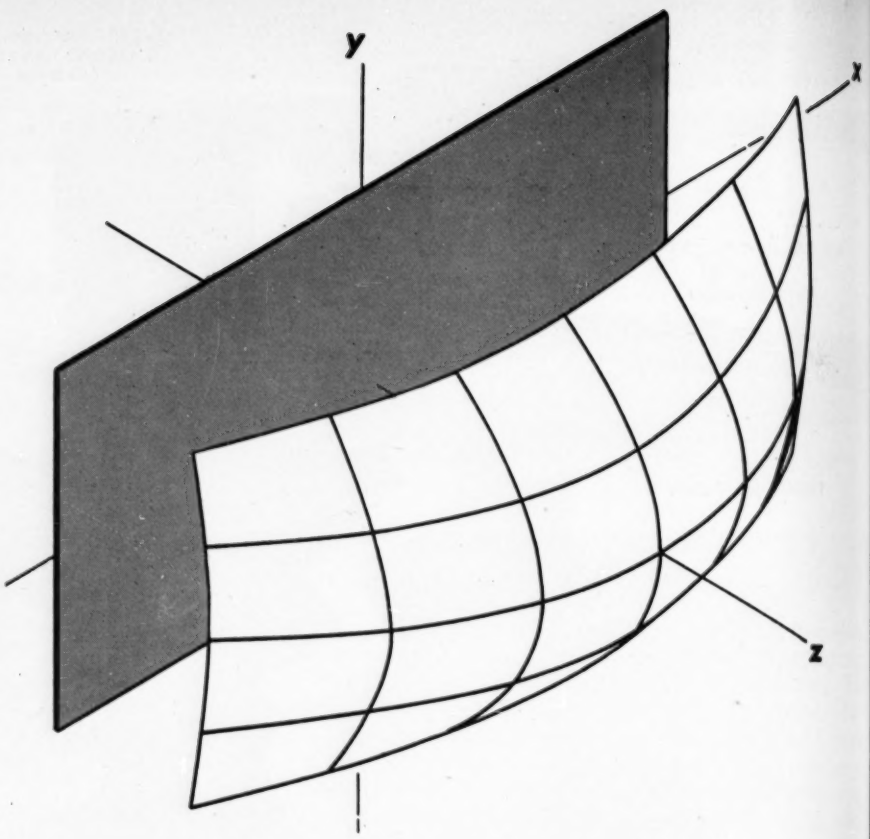


Fig. 3. Section of a typical isodose surface generated by a finite plaque source of uniformly concentrated activity.

The relative value of gamma sources having different half-lives might be expressed in terms of some function of the ratio of the half lives. The nature of this function will be discussed briefly with regard to: total dose delivered, replacement time, average source strength, and relative cost proportional to half-lives.

It can be shown that radiation value can be considered to be approximately proportionate to half-life based on total dose delivered. In analyzing further the relative values of isotopes having different half-lives in regard to replacement costs, it can be shown, that the number of curies required at each replacement will be the same, independent of half-life. Thus, the total number of curies required to maintain operation at a given rate for a considerable period of time would be inversely proportional to half-life.

By accepting the relative value of gamma sources having different values of half-life expressed in terms of linear ratios of the half-life values, cerium-144 might be considered to have 290/365x33 or about 2.4% of the dollar value of cesium-137 as a gamma source over a long-term bases. Similarly, cesium-137 would have 33/5.5 or 6 times the value of cobalt-60. These ratios are based on the supposition that the radiation facility would be operated for a sufficiently long time to take advantage of the longer half-life of cesium-137 as compared to cerium-144 or cobalt-60. However, if the facility is to be depreciated in five years or less, the ratio of the relative values will approach unity. Thus, for a very short irradiation program all radioisotopes having the same energy would be of equal value.

Feasibility Studies

A variety of applications of gamma radiation to industrial processes and to medicine have been considered in several

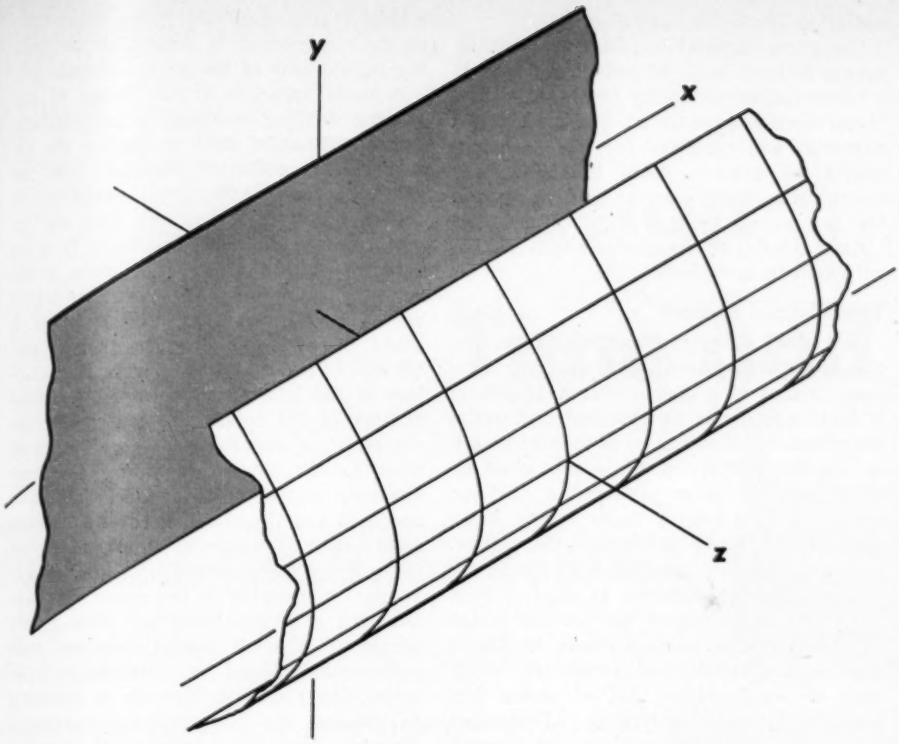


Fig. 4. Section of a typical isodose surface generated by a semi-infinite strip plaque of uniformly concentrated activity.

feasibility studies prepared by personnel of the Fission Products Laboratory at the University of Michigan. The purpose of these feasibility studies has been twofold. First, was the demonstration of some of the applications of gamma radiation considered technically feasible and the type of radiation facilities possibly involved; secondly, was the presentation of the methods of design which might be used to take better advantage of the unique properties of gamma radiation sources.

Radiopasteurizing Meat

The first of this series of studies was made of a gamma-irradiation facility designed to irradiate whole, slaughtered hogs to control trichinosis. The second study was for an irradiation facility, shown in Fig. 1, designed to "radiopasteurize" prepackaged fresh meat so as to permit cutting and prepackaging of unfrozen meat at the packing houses rather than at retail stores. The feasibility of this method depends on the extension of the refrigerator shelf-life of fresh meat by radiopasteurization. Recent trends in retailing meats and the economics of meat processing suggest the desirability of prepackaging.

Three design studies were presented for gamma-irradiation facilities to process potatoes in bulk with a radio-subpasteurizing dose for sprout inhibition. Northern grown potatoes are available only about eight or nine months of the year because if stored for longer periods sprouting occurs followed by rapid deterioration. Tests with irradiated potatoes have demonstrated that irradiated mature northern potatoes can be kept in refrigerated storage from one year until the next, thereby making desirable types of mature potatoes available the year around.

In another study a preliminary design was presented for an irradiation facility for treating 100-pound bags of grain, flour or meal for control of insect infestation. Insect infestation results in a tremendous loss of stored grain, flour, meal and cereal products estimated at $300,000,000 annually. Studies at Michigan State University on typical insects which infest cereals indicated that a 10,000-rep dose of ionizing radiation was sufficient to sterilize the eggs and prevent adult insects from reproducing.

A "new" process of food preservation has been given limited study and appears very promising as a means of increasing the refrigerator storage life of a number of perishable foods. In this process, foods such as meats and vegetables are precooked or blanched, respectively, then packaged in retail-sized portions in 2-mil polyethylene bags, heat sealed and given a one-megarep dose of gamma radiation. This radiation dose is not sufficient to sterilize completely but is sufficient to reduce the number of vegetative organisms, molds and yeasts that cause rapid spoilage even under refrigeration.

In addition to these studies of gamma-irradiation facilities for the commercial processing of food, studies also have been made of irradiation facilities to promote chemical reactions, to sterilize bulk medical supplies, and to sterilize bone-bank bone, other homograft material, and miscellaneous surgical and hospital items.

Radiation as Chemical Catalyst

A limited number of chemical reactions of commercial interest are known to be promoted by gamma radiation. Among these the chlorination of benzene and toluene and the polymerization of monomers such as ethylene are most promising.

The chlorination of benzene in the presence of gamma radiation was considered in one of the feasibility studies. This reaction is a chemical chain reaction and requires only a small gamma source. The product is benzene hexachloride which is a valuable insecticide. Preliminary feasibility studies indicate that gamma radiation can compete with the present use of ultra violet radiation to promote the reaction profitably.

As pure hydrocarbons do not become lastingly radioactive as a result of neutron bombardment, reactor cores might be used as sources of radiation. Certain reactors might use an organic fluid as a coolant. This fluid or organics dissolved in this fluid might undergo chemical change as a result of irradiation in the reactor so as to produce a valuable chemical by-product while performing the cooling function. Heat for power or process heat could be removed from the fluid as well as the chemical by-products. The latter might be removed by centrifugation or distillation. Although such applications may prove feasible, only limited studies have been made in this field. These possible opportunities remain to be explored.

Selecting Geometry of the Source

A point gamma source has a radiation field in which the isodose surfaces are spherical shells. If the radiation is to be absorbed uniformly, the absorber must also be spherical. It is very difficult to arrange a conveying system in which any absorber would be conveyed so as to produce a pattern of a spherical shell. Thus the problems of geometry are very difficult with a point source. There is one exception, the case of a fluid used as the absorber. If a fluid such as a beverage product were irradiated in the bulk state, a point source with successive spherical shells through which the fluid passed would be a reasonable design. Obviously, the single point source has very limited possibilities for use in the irradiation of commercial products.

A rod source has some advantages over a point source, but has the disadvantage

that symmetry is lost for a rod of finite length. The absorber should be cylindrical, which is more feasible from the standpoint of mechanical conveying than is the spherical shell. Grain might be allowed to flow through an annulus surrounding a rod source using gravity feed. Other items that cannot be easily moved by gravity might be conveyed by means of a helical screw in the annulus. A single rod source is almost as limited as a point source for use in the irradiation of commercial products. However, a group of rod sources may be arranged as a plaque source or annular cylindrical source to great advantage.

An annular cylindrical source has essentially the same characteristics as a rod source with regard to the radiation field surrounding the source. If the temperature rise as a result of self-absorption of radiation (particularly betas) within a rod source becomes a problem, the annular cylindrical source (hollow rod) can be used to advantage. The greater surface area of the annulus permits greater heat transfer away from the surface. Also, the decrease in source thickness results in a smaller temperature gradient across the source.

The annular cylindrical source, as shown in Fig. 2, provides an essentially uniform radiation field within the cylinder and, therefore an absorber in this portion, will receive uniform dosage throughout with no rotation or conveying required during irradiation. Such a condition is ideal for batch irradiations. Most laboratory gamma sources are designed for batch irradiation and, therefore, have utilized the annular cylindrical source. All three of the powerful gamma sources on the University of Michigan campus are annular cylindrical sources. The two larger sources consist of rods arranged in a circle so as to produce a hollow cylinder or annulus.

If only the radiation field within the annulus is utilized, most of the radiation (from a minimum of 50% to over 90% depending upon the diameter of the annulus and absorber material) will be dissipated in the shielding. Small laboratory annular cylindrical sources in lead pigs are very convenient to use, but if no provision is made for utilization of the radiation outside the cylinder, less than 10% of the radiation is usefully absorbed.

Using an annular cylindrical cobalt-60 source formed from 36 rods, we designed a batch radiation facility for hospital use. It can sterilize bone for bone banks, arterial segments and cartilage for use as homografts in surgery; other items such as instruments, dressings, etc.; and for possible use as a research source. Both the radiation within the cylinder and a portion without can be utilized.

The Plaque Source

The most adaptable geometry from the standpoint of conventional conveyor systems is that of a plaque source. However, if irradiation is to be absorbed uniformly, the plaque must either be of infinite length or else the activity of the source must be distributed so as to produce an uniform radiation field over a finite length along an axis parallel to an axis of the plaque. Isodose surfaces generated by different plaque sources are shown in Figs. 3 & 4.

By proper spacing of the activity in the strip, the isodose surface shown in Fig. 4 can be simulated. One procedure which may be employed is that of using fuel elements or tubes containing radioisotopes arranged in a plane and parallel to each other but with nonuniform spacing if each rod or element has uniform activity. For the case of uniform activity, the arrangement shown in Fig. 5 was developed and it shows the ends of 10 source rods that constitute one-half of an "equivalent plaque". The nonuniform spacing of the rods was determined by trial and error. The smaller pitch near the end is used to produce a more uniform radiation field at the extremities of the plaque included in the plane of the source.

For the design of a "high-radiopasteurization facility" using the fuel-element spacing shown in Fig. 5, food was to be transported to the chamber on a conveyor in a number of vertical passes. Therefore, it was decided to establish a uniform radiation field in a horizontal direction. Thus, although the food is conveyed to a varying radiation field in a vertical direction, the uniform horizontal field assures that the food on the ends of the conveyor receive the same dose as the food located in the middle of the conveyor, if the lateral axis of the conveyor is a fixed distance from the lateral axis of the source plaque.

A basic principle in the design of any gamma facility utilizing a non-uniform gamma radiation field is placing the absorber at a sufficient distance from the source to reduce the great variations in the radiation field resulting from the inverse square relationship. Thus, it is an error to place the absorber close to the source so as to take advantage of the higher radiation field. A given thickness of a given absorber will absorb a given percentage of the radiation striking it, regardless of the intensity. Therefore, the same portion of the total radiation will be absorbed at a distance from the source as close to the source, providing the same absorber material and absorber thickness are used and the absorber covers the same solid angle. Of course, moving the absorber away from the source requires a greater volume of absorber in the radiation chamber and a larger "hold-up" time in the chamber. A good design requires some compromises based on engineering judgment. The radiation capacity is optimized by placing the absorber an appropriate distance from the source. Consider an absorber placed close to a gamma source. The radiation field is higher near the source but it is also changing very rapidly with distance because of the inverse square law. Thus, in order to secure a minimum desired radiation dose in the center of the absorber, an appreciable overdose must be tolerated on and near the surface when the absorber is too close to the source. This overdose represents wasted radiation absorption which not only fails to serve a useful purpose but may result in undesirable effects induced by overdosage. On the other hand, placing the absorber away from the source results in a much more efficient use of the radiation that is absorbed and as the same fraction of the total radiation can be absorbed, the total capacity increases.

Another fundamental principle in the design of such facilities is the irradiation of the absorber from both sides so as to increase the uniformity of dosage. The irradiation from either side need not occur simultaneously and usually is more conveniently performed in series when using a conveyor system. Fig. 1 demonstrates one of the methods considered.

For the Future

In the future commercial gamma radiation may have as dramatic an effect on the nation's economy as is predicted for nuclear power. Technical management must be prepared for this change by training the designers of the facilities and alerting the engineers who will be concerned with the processes. The job of integrating this new engineering tool into our industry is a challenge for the entire technical community. END

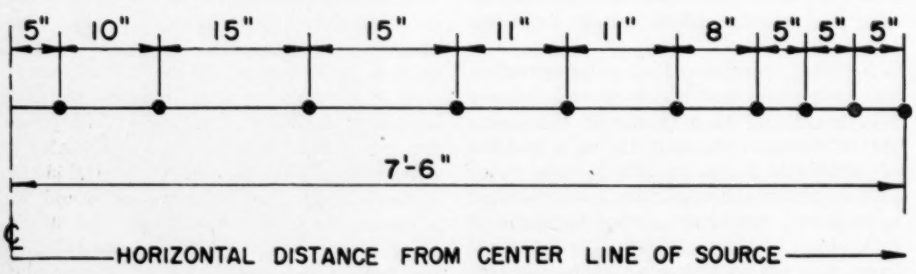
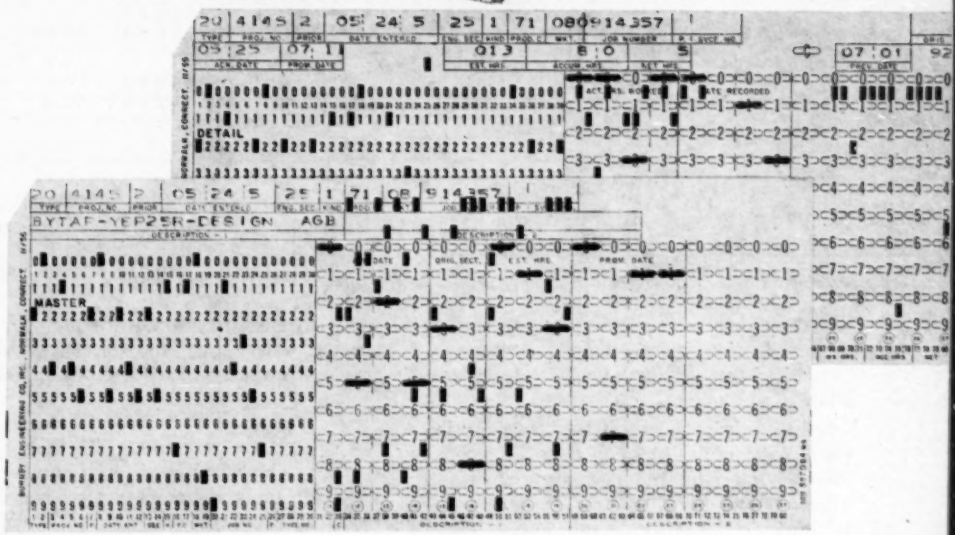


Fig. 5. Plane view showing spacing of one-half of fuel elements for irradiation facility for "high radiopasteurization".

Design Time and Money:

Punched Cards for Control

Only 2% of the time of your firm's accounting machine set-up is required weekly by this system to tell how much each R & D project is costing and if it is on schedule. The results help in estimating costs and duration for new projects, and facilitates decision-making.



Gerson Friedman and Isaiah Eisen

When several hundred design and development projects are in progress at the same time, it is impossible for technical management to quickly summarize the status of all the jobs. Here we tell how the Burndy Engineering Company, Inc., of Norwalk, Conn., utilizes only two percent of the time of its 30-man tabulating room plus one intelligent young lady to provide management with compact weekly summaries of the time and cost status of each R & D project. At a glance, the Chief Engineer can tell if a project is on schedule, how much money has been spent on it, and which projects were completed or started in the past week. In addition the punched-card tabulating machines can be used to provide a number of comparisons with past projects to determine long-time trends. The system is flexible enough to be adapted to firms either larger or smaller than Burndy. A manufacturer of electrical connectors, Burndy has 1400 employees.

Outgrowth of a Manual System

The present mechanized control system is based on a manual control that grew up over a number of years. Each project was recorded separately under the former system. The tabulating room had been in operation for two years when the new system was put in effect in September, 1954. All employees covered by the system were given careful indoctrination before it was put into effect. For the firm's 150 engineers and technicians, the new system only meant a change in the way they kept their records, although they had to account for time more carefully. Some mild objections were voiced by engineers who felt they were being burdened with more paper work. Management accepted the system quickly; the authors didn't have to fight for acceptance. In a few months the system had shaken down and was operating smoothly in both personnel and machine aspects. Since September 1954, a few changes and improvements have been made, but there is no question that everyone has now accepted the system and respects it. No major changes are expected.

What the System Offers

- The first and most important weekly report prepared is the "Status of All Work". Each engineering section supervisor receives a copy listing about 150 projects—the current load.
- A second weekly report prepared is the "'Backlog and Schedule Report". Here each

			TYPE OF WORK	PRIORITY	DESCRIPTION	DATE ASSIGNED NO./DAY/YR.	PROM. COMPL. DATE NO./DAY	EST. HRS.	HRS. TO DATE	WEEKLY HRS.	NET HRS.	PRODUCTION ORDER NO.
		6	20	3	HYPRESS-							
21	4106	20		3	OPERATED-DEV-HOUSE-SB	4215						
21	4106	20		3		4215	530	70	74	12 0	4 CR	
21	4113	20		3	HYSPLIC-SMOOTH BDY-6ACSR							
21	4113	20		3	DES- -WR	4285						
21	4113	20		3		4285	801	27	6	1 0	21	
21	4115	20		2	UNDRGRD ADAPTOR-350MCM							
21	4115	20		2	AL-DESGN- -MM	4285						
21	4115	20		2		4285	808	20	6	1 0	14	
21	4120	20		2	LINKTS-YSU-R-R-VAR CABL							
21	4120	20		2	COMBO- -HS	5055						
21	4120	20		2		5055	926	31	3		28	
21	4123	20		3	HYTOOL-MD3-G C GROVE 6 4							
21	4123	20		3	HYSPL DES- -WR	5055						
21	4123	20		3		5055	613*	49	16	1 5	33	
21	4125	20		3	HYPRES 8 IN DIA DIE BLNK							
21	4125	20		3	-DES-COST JB	5055						
21	4125	20		3		5055	627*	30	5	7	25	
21	4127	20		2	DIE SETS-U-RT-COMPLETE							
21	4127	20		2	DESIGN OF LINE-HSE-JTG	5095						
21	4127	20		2		5095	808*	16	6	7	10	
21	4139	20		2	CRIMPIT COVER DEVELOP-OF							
21	4139	20		2	CO-JTG	5205						
21	4139	20		2		5205	530	32	54	26 0	22 CR	
21	4145	20		3	BYTAP-YEP25R-DES-							
21	4145	20		3	PWR LT-AGB	5245						
21	4145	20		3		5245	711	13	2	2 0	11	914357
21	4146	20		2	HYPRESS-Y29B-REVIEW FOR							
21	4146	20		2	USE IN COMM CABL-HSE-LG	5245						
21	4146	20		2		5245	801*	25	3	3 5	21	
21	4147	20		3	DIE SET-U28RYRT-2-DESIGN							
21	4147	20		3	LT- -AGB	5275						
21	4147	20		3		5275	718	10	2	2 5	8	648562
										94 5*	663	55
										TOTAL WEEKLY HRS SECTION	TOTAL NET HRS. LEFT IN ESTIMATE	TOTAL ACTIVE ITEMS

The first and most important weekly report is the "Status of All Work" above.

of the items of work in each section are listed section by section in sequence of promised completion dates, with the earliest date first.

- The third report is the "New Projects and Completions", which lists the seven to ten completions and new assignments for the past week.

Cost is indicated in the weekly reports only in man hours expended. In preparing the monthly reports, the time figures are converted by the IBM 607 calculator into dollars. The conversion is based on a weighted dollar rate per hour set for each engineering section by the accounting department. This "loaded" rate includes overhead for the Engineering Department.

- The first monthly report is called the "Product Class Hour and Dollar Monthly Report". It shows hour and dollar cost figures in product class sequence.
- The "Section Hour and Dollar Monthly Report" is distributed to section heads to tell how time was spent on projects in their respective groups.

Other control summaries can be produced and some are under consideration. An example is a "Redesign Summary". It would compare the cost of redesigning a product or process with the initial design cost. If redesign costs were high in comparison, this might indicate that an entire class of products was poorly designed.

How the System Works

The system starts with the "Work Order", which initiates a design project. In the tabulating room, a punched-card operator produces two punched cards for that project. All of the parts of the "title" and "detail" punched cards are sent to the administrative aide. This young lady works in the main without requiring much supervision from one of the authors. She is part of the "Administrative Section" of the Engineering Department. The system also accounts for supplementary services such as drafting, sample-making and testing.

At the end of each week, each engineer and technician fills out a mimeographed weekly "Time Sheet" indicating how many hours were devoted to each project. All time sheets are sent to the administrative aide. She manually marks with an electroconductive lead on each project "detail" card the hours devoted by each engineer and the code number. The detail cards are then sent back to the tab room where the machines total the hours and punch them into new detail cards. Detail cards from the previous week are filed for reference for a short time.

Tab-room personnel can now run these cards through the machines in different ways to produce the weekly and monthly summary reports in original and as many duplicates as are required for internal distribution.

Standard IBM forms are used for the summaries. A stock punched card with over-printing has been used to date, but specially designed cards are to be introduced shortly.

Most of the work of the administrative aide is repetitious but intelligence and discretion are called for since unpredictable elements sometimes appear. It took only a few months to train this young lady. A total of 50 hours per month of calculating machine and operator time is required for the system.

What Can Be Done With the Reports?

The main value of the Backlog & Schedule reports is an aid to the supervisor or manager in expediting. Working from the top of the list down, the manager or supervisor assists in breaking bottlenecks, keeps the work of his group up to date and moving. At the same time, items which cannot be rushed for good reason are clearly shown

and can be carefully watched.

"New Projects & Completions" report serves as a news release to Sales, Advertising, Manufacturing, Top Management, and Branch Plant Executives to keep them informed of the nature of work undertaken and completed by Engineering. In the case of new project work, this serves as a means to trigger questions on how the groups may be concerned *very early* in the life of a project. This also informs all concerned of the priority of the assigned work and thus gives an idea of its relative importance compared with other work.

Certain copies of the report are marked up to show the cost of Engineering Department time spent on the completed projects. These copies are distributed to members of Engineering Management for their information and for background on expected costs of future projects of a similar nature.

The "Status of All Work" indicates the number of items worked, the amount of time on each, and the status of items according to the schedule and time estimate. The latter is extremely important where manufacturing orders are involved. This report also gives a quick indication of work load and helps to determine how much work a group can accept. It is issued early each week and reflects work status as of the end of the previous week. In addition to each affected engineering supervisor, copies of the complete report go to the Chief Administrative Engineer and Assistant Chief Engineer to give them an overall picture at a glance.

"Product Class Hour & Dollar Monthly Report" provides Engineering Management with the data for apportionment of engineering expense to product classes.

By judicious use of both weekly and monthly reports, excessive engineering costs are quickly spotted and rapid action by the Engineering Supervisor and Engineering Management brings the situation under control.

The System Can Be Adapted

Although the system has not been copied by any other firm, we believe it is readily adaptable to almost any of the special problems which a medium or large size engineering organization may face. It provides the means for efficiently gathering a great many facts and assembling them into usable form. The system for engineering control cannot justify a company's going into the investment which tabulating equipment requires. However, Burndy management was quick to realize the benefits to be gained using this equipment from the other company applications of it.

The true effect of this or any other system, however, still depends on the use the Research and Development Manager makes of the facts at his disposal in controlling and guiding his operation. Control is still exercised by the individual, not the machine.

END

NEWLY ASSIGNED PROJECTS

```
22 4109 10        3 BANDLG STRP-2PRONG-SECUR
                    TERM-OEM-AIR-GC                4265
23 4110 10        3 FLAG TERM- YBV-YBM-
                                  -FDD             4265
31 4111 10        3 PRIM TRNSF TERM-KC25GX
                    QUOT-DWC-                -ML   4265
21 4112 20        3 DIE SET-U6WKYDT-DESIGN
                                PWR-NP             4265
21 4113 10        3 HYSPLIC-SMOOTH BDY-6ACSR
                    DES-                 -BRCN-WR  4285
23 4114 10        3 HYRINGS-YOC-Y1C-REVIEW
                    SPEC ON-OEM-AIRCRAFF-ML        4285
21 4115 10        3 UNDRGRD ADAPTOR-3SOMCM
                    AL-DESGN-                -NY-MM4285
32 4116 10        4 FLEX BRAID CON-XFL-PREP
                    QUOTE                -XPORT-AEB4295


                                                   CR
                                                   CR

                  PROJECTS CLOSED OUT AND
                  CANCELLED


21 3371 20        2 CRMPT-LINE CONN-REA APPR       CR
21 3371 20        2 -ELTAPS  HSE-RHARAP      1135CR
21 3371 20        2                          1135CR2000    80     2

21 3371 20 4      2 CRMPT-LINE CONN-REA APPR
21 3371 20 4      2 -ELTAPS  HSE-RHARAP     12164CR
21 3371 20 4      2                         12164CR 606*   18    11

22 3595 10 2      3 HYPST N DIES-259-0311
22 3595 10 2      3 653 OD CABL        -AA   3114CR
22 3595 10 2      3                          3114CR 502    52    51

23 3686 10        3 HYTL-YMRE TYP-FLAT CRMP
23 3686 10        3 YAE22-             -BBB  5114CR
23 3686 10        3                          5114CR 328*   45    44
```

Serving as an internal news release, the "New Projects and Completions" indicates priorities for projects.

SECTION	PROJ. NO.	TYPE OF WORK	SERVICE NO.	PRIORITY	DATE ASSIGNED NO./DAY/YR.	PROM. COMPL. DATE NO./DAY	PRODUCTION ORDER NO.
80		08	382	3	1206	213	
80		08	388	3	1256	220	690774
80		08	390	3	1266	220	
80		08	397	3	1316	220	
80		08	403	3	2036	220	691837
80		08	405	3	2066	220	
80		08	406	3	2066	220	688627
80		08	407	3	2076	220	
80		08	408	3	2086	220	
80		08	411	3	2106	220	
80	4293	28	404	3	2066	227	
80		08	414	3	2136	227	
80		08	217	3	9155	305	
80		08	304	3	11285	305	
80		08	409	3	2086	305	
80		08	415	3	2166	305	695700*
80		08	416	3	2176	305	923145
80		08	391	3	1276	326	691754

Glancing down the second column from the right tells how close each project is to promised completion date on this "Backlog and Schedule" report.

GERSON FRIEDMAN

ISAIAH EISEN

Starting at Burndy in 1948 as an Engineering Trainee, Mr. Friedman has moved up through the grades to his latest appointment as Senior Planning Engineer of one of the firm's two divisions. During this time he added a master's in industrial engineering to his basic degree in E.E. Since joining Burndy right after World War II, Mr. Eisen has moved from engineering into finance. Formerly in charge of the firm's laboratory, he is now Planning Coordinator reporting to the Treasurer. A mechanical engineer, he has also received a master's in industrial engineering.

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Research Administration

MERRITT A. WILLIAMSON

In the course on Research Administration which I give at the University of Pennsylvania, I have one lecture devoted to the "Philosophy and Objectives of Industrial Research". The objectives are many and may be variously stated but they are all practical and easy to understand. The philosophy, however, is not so easy to express. In thinking about this subject I have come to the conclusion that there is no *one* philosophy but many which depend on the individual, his position in the organization, his background of education, and his training.

If I were going to state the philosophy of industrial research from the point of view of the business man, who after all puts up the money we spend, I would have to say that "business is in business to make money". An industry will spend money in the present if the money will be returned with interest at a later date. In the 60 years of industrial research in this country it has been demonstrated that research expenditures do obtain a return. This is not to imply, however, that each project is successful but rather that the successful ones succeed so well that they pay for the commercial failures. These commercial failures may be highly successful technically and they may be responsible for commercially successful projects in the future.

The Philosophies of Business

There are many philosophies of business. They are not all incompatible, but they may be quite differently expressed depending on the level of sophistication. It seems to me that business exists primarily to make a contribution to the enjoyment or welfare of society and that as an incidental part of fulfilling needs and desires, profits do accrue. In fact, the better the demands are satisfied, the greater will be the profits under our capitalistic system. A business will fail if it contributes nothing. Profits may then be regarded as measures of success in fulfilling society's demand for our goods or services.

Looked at in this way, the objective of research is basically to add to the enjoyment and satisfaction of life. If our buying public does not see a new development as providing any enrichment, it will not reward the producer by making purchases. Money, under this view, enters only as a medium of exchange and not as an ultimate objective in itself. Prices expressed in money, then, are a reflection of the degree of satisfaction which the object purchased will provide the buyer. You may think that this is philosophical sophistry and that, interesting though it may be, we research managers deal with hard-headed business men who aren't in the slightest concerned with enriching life and enabling more people to live more fully. The marketing men know full well, however, that the demands of the public are very real and are a prime consideration.

Research and the Monetary Return

Getting back to research, we, as research and development managers, do not sell a research program on its uplifting features. We sell it on the prognosis that dollars will come pouring into the till as a result. Our research plans must therefore be so presented that the probability of monetary return appears to be good. The further one backs up from product or process improvement into the realm of basic, fundamental, or non-applied research, the more uncertain becomes the relationship between satisfactory results in a technical sense and profits rung up on our cash register.

Many formulas have been developed to determine the probobility of commercial success. To the highly analytical, exacting physical scientist these are ungratifying. In these formulas there is always a factor which involves an appraisal of the future and this is only as good as the forecaster's ability to make accurate assumptions about the future. To me, the result of these formulas is really only transforming a hunch into a quantity. If the forecaster has a record of success, I am just as well satisfied with a qualitative statement.

However, there is a definite advantage in reduction to a number or a percent, and I think this should be recognized. Management expects its scientists to work in the realms of exactness. A "number" to the accounting and financial-minded executive carries with it a degree of confidence. And isn't half our battle as research and development managers the establishment of ourselves in the confidence of the rest of management who are not equipped to assess the technical climate? If these formulas work for this purpose by all means let us use them, but let us be sure that our forecaster is the most gifted man we can locate. And we should not delude ourselves by the illusion of exactness which figures are apt to convey.

Relating Profits to Job Satisfaction

Now how do we relate the business man's insistent search for dollar profits to the scientists' and engineers' satisfactions? As D. H. Voorhies wrote in his booklet, *The Coordination of Motive, Men and Money in Industrial Research* published by the Standard Oil Company of California in 1946, "The satisfaction of scientific curiosity is not the fundamental basis upon which modern industrial research is founded". This is where we research and development managers come into the forefront to take the objectives of business, translate them, alter them, disguise them, and represent them in such a manner that the fundamental drives of our people will be gratified by their conduct. At the same time we are carrying our organization forward in the

direction that management wishes it to go for greatest profitability.

Here we must call into play our skill with people. Some research men, perhaps many, have a burning desire to see the stockholders get greater dividends, or they want to see more profits ploughed back into equipment and facilities. Others crave recognition. They want a "thank-you", not from management as a general concept, but from the person who pays them, evaluates their work, and represents their interests in the competition for top management support. Still others may want to gratify their curiosity; we must be sure that these workers become curious about the appropriate problems which push our companies ahead. Any manager readily recognizes what is implied by this "unity out of diversity", and this challenge is nowhere so great in business as in research.

The strength of our capitalistic system, it seems to me, lies in the fact that idealistic concepts on the part of each citizen are not necessary; but appeal to the more mundane motives results in general betterment since society as a whole decides what it wants and rewards those who satisfy these wants. Where the state decides what is best, the total satisfaction on the part of the citizens is never and can never be maximized. In a planned economy, how can a master mind (or minds) determine the ratio of corn to potatoes or automobiles without access to a free market to determine the people's assessment of what is wanted?

Relation of R & D Costs to Profits

In *Business Week* for February 25th of this year, it was announced that a leading economic consultant, Lionel D. Edie, had made a striking discovery: Since World War II the industries that have spent the most money on research and development have seen their profits grow most, while those that spend least on research, gained least. (Ed Note: See *Research and Development for Profit: Report on National Industrial Research Conference,* page 18)

Business Week predicts that economists and statisticians are certain to quarrel about the exact meaning of Edie's report. It might be coincidence. It might be that research is an incidental aspect of growth rather than a cause of it. It might be that an astute management skilled in business had for some reason an unfounded predilection for research. To those of us in research and development management, however, these figures do not come as a surprise, and they are certainly helpful in selling our managements on continued support of research. They do not tell us, however, what percentage of gross sales should be devoted to research in our particular situation. Nor do they tell us how to assign the value of research and development efforts in comparison with engineering's, manufacturing's and marketing's efforts leading to the sale of a commercially successful product.

Some Pertinent Questions

This month I have decided not to present a case but rather to pose a series of questions on which you are invited to respond. This issue of RESEARCH & ENGINEERING may contain some of the answers but I am sure that there are many more. You can perform a real service to your fellow research and development managers if you will send along your thoughts on these matters. I am most interested in seeing what principles of management may be evolved. A good manager, like a good boxer, should have many techniques and not just wade in every time with a left hook. Let me hear from you.

1. Do you think that an appeal to company profit motives is effective in motivating research and development personnel? Under what conditions? What techniques can be used to emphasize that research must contribute to profits?

2. How do you as a research and development manager make sure that the contribution made by your department to company profits is recognized? How do you measure it? What accounting procedure, evaluation, or formulas do you use? On what assumptions are the formulas based? Who has to concur and how do you obtain concurrence in their validity?

3. Is a plan for profit-sharing sound when applied to an industrial research and development organization? What basis can be set for awards? Should it be a uniform percentage of salary or should it be based on contributions? How would relative contributions be determined? What levels of employees should participate? How would administrative contributions be balanced against technical contributions?

Frank Davis's Dilemma (Cont'd)

This case (presented in the March issue) has elicited more comment worth reporting. Johan Bjorksten of Bjorksten Research Laboratories, Madison, Wis., offers the following: "In order to prevent disintegration of Bill's group, the following moves might be indicated: (1) When Bill is told about his promotion, he will be in a receptive mood, and this would be the occasion for discussing with him frankly his personality problem. This may help some, and may assist in bridging the transition. (2) We would give Bill a capable secretary of good personality, with the specific instruction both to her and Bill that her function will be to handle as much as possible of the contacts of an administrative nature, and generally supplement diplomacy in personnel handling. A really good secretary could perhaps save the situation. In the event that Bill's work should not warrant a full time secretary, she might also handle some of the work of the other project leaders; however, she should be fully aware of the reason for her assignment. (3) To some extent it might be possible to work into Bill's group persons of easier personality."

Richard S. Davies of the Research Division of Philco Corp., Philadelphia, Pa., says he would proceed as follows: "... I would first promote Bill to the position of project engineer but rather than give him the project administration responsibility, I would give him the position of staff consultant reporting directly to Frank. In this position, the responsibilities would be purely technical. The project leaders would approach Bill with technical problems and Bill would be able to to use his abilities to solve them. It is important, however, that Frank sell Bill with the idea that he is not being slighted by not being made an administrative head but rather that his technical responsibilities will be in so much demand that he would not have time to attend to administrative work. I would then bring in a new project engineer proved in administrative ability to head the project which Bill had."

Tom Knight of Westinghouse Appliance Division, Mansfield, Ohio, observes that the answer to the problem "is not to be found in the managerial but in the physical. Bill's physical conditions, while possibly chronic, might be improved. Frank's concern for Bill's ulcers and gentle insistence that he visit his doctor for a check might prove the answer."

Clarence R. Acker of Line Material Co., Milwaukee, Wis., looks back of the case and points out that three basic rules may have been violated resulting in the difficult situation portrayed: "(1) Lack of definition of title or position, (2) assigning a task at the wrong level, and (3) lack of delegation of complete authority." As a solution, he too believes that much could be accomplished by having Bill obtain medical treatment. "Current with his physical rehabilitation, Bill should be educated in personnel relations and administration so that he will be a well balanced supervisor." Acker advocated that Frank take Bill aside and explain the entire situation to him, accepting the responsibility for having assigned him technical authority but not giving him administrative authority. He asks, "How could Frank expect the five engineers and five technicians to look upon Bill as their supervisor?" After this tete-a-tete, and when Bill is physically and educationally fit, Frank should bring Bill and his engineers and technicians together and explain what has happened. In so doing not only will Bill and his men get started on the right foot, but the company will get in solid with the men. Acker predicts that "This explanation, if handled in the proper manner, will result in a *team* which very likely will out-perform either of the two already existing groups."

(Please address replies to Dr. Merritt A. Williamson, % RESEARCH & ENGINEERING, 77 South Street, Stamford, Conn. Your name will be withheld on request.)

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R/E views the books

The Open Mind

BY J. ROBERT OPPENHEIMER

Reviewed by Samuel Hobbs, Associate Editor

Whenever the birth of the atomic bomb is discussed, the names of two men are likely to be mentioned: Einstein and Oppenheimer. Like Einstein, J. Robert Oppenheimer is a scholar as well as a scientist; he is in addition a controversial genius who has been called the "father" of the atomic bomb. Perhaps no man now alive has a keener insight into the subject of nuclear power, both from a political and scientific point of view, and within a framework that knows no national boundaries.

Oppenheimer has been in hot water on at least two occasions. He was publicly accused of impeding the development of the H-Bomb, on the ground that it was too monstrous a weapon to contemplate. Again, in 1954, in a much-publicized proceeding, he was denied security clearance by the State Department.

What kind of man is the author of *The Open Mind?* Most important, he is a gifted philosopher as well as a scientist. Like Einstein, he has the ability to speak clearly, simply and convincingly of his beliefs.

Oppenheimer is convinced that open-mindedness on the part of our government and governments everywhere is one of the keys to world survival. If this book has any theme, it is the value to society of the open mind, and the necessity for cultivating such open-mindedness.

Physically, Oppenheimer is an impressive man. He is tall and spare, Lincolnesque, with crow's feet at the corners of his eyes; one imagines that his is the kind of face that is frequently wreathed in smiles.

His greatest renown, of course, lies in his reputation as one of the world's most knowledgeable physicists. To this must be added the unique administrative skills that culminated in the "crash" development of the atom bomb.

Oppenheimer is also a diplomat. In addition to his work as director of the Institute of Advanced Study at Princeton, N. J. (since 1947), he has also served in many advisory positions to the government.

This, then, is a brief profile of the man who wrote *The Open Mind.* In it lie the clues to the basic meaning of the book for thinking Americans and for the rest of the world as well.

The book concerns two complementary subjects: atomic weapons and the relationship between science and the wider culture of our times. It is made up of eight lectures given by the author during the decade since the end of the war. These eight lectures show the scope and depth of the man's thoughts; how some of his ideas changed and expanded over the period covered; and how, with crowning simplicity, he reviewed the world's arts and sciences in the concluding lecture, delivered at Columbia University's Bicentennial in 1955.

THE FUTURE OF ATOMIC EXPOLOSIVES

In discussing the future of atomic explosives in 1946, less than a year after the doom of Hiroshima and Nagasaki, Oppenheimer said: "There is only one future of atomic explosives that I can regard with any enthusiasm: that they should never be used in war."

In this chapter the author goes on to discuss his hopes for international control of atomic energy. (This was 10 years ago; the current disarmament and atomic inspection and control talks in London have produced nothing much more concrete, with the exception of the "open skies" proposal, than what Oppenheimer initially proposed.)

In discussing means for control, Oppenheimer is cognizant of the limitations imposed by the sovereignty of nations; by the fallacious thinking that a supra-national state would be an immediate answer; and, of course, by existing Soviet attitudes. International action is necessary, he says; ". . . the study—but not the production —of atomic weapons, and inspection to prevent the illegal mining of uranium, both . . . seem to be essential functions of an international authority."

To his proposal of an International Atomic Development Authority (an idea which President Eisenhower has so successfully elaborated on), Oppenheimer suggests that in a world of sovereign nations, "there are only two ways in which this can ever be possible: one is conquest, that destroys sovereignty; and the other is by the partial renunciation of that sovereignty. What is here proposed is such a partial renunciation, sufficient, but not more than sufficient, for an Atomic Development Authority to come into being, to exercise its functions of development, exploitation and control, to enable it to live and grow and to protect the world against the use of atomic weapons and provide it with the benefits of atomic energy."

THE RUSSIAN VIEW

What of the Russian attitude toward such a proposal? Said Oppenheimer in 1947: ". . . I think no one can take with any seriousness the hope or expectation that the Soviet Union will accede . . . to what is now the majority plan . . . That is because the proposed pattern of control stands in a very gross conflict to the present patterns of state power in Russia."

What Oppenheimer said in 1947 is true today, even though the Geneva "spirit" has masked for some people Russia's unchanged intentions. For while the Soviets may seem to accede in principle to the disarming of men, the cut-back in munitions manufacture, and the radical "open skies" idea, they have not abandoned their fundamental methods of achieving world supremacy.

THE OPEN MIND

According to Oppenheimer, "the field of atomic energy is an open-book examination. It is something where you can't look up the answers, and where your real assets are assets of capability, understanding, knowledge and competence.

"We have a natural sympathy for extending to foreign affairs what we have come to learn so well in our political life at home: that an indispensable, perhaps in some ways *the* indispensable element in giving meaning to the dignity of man, and in making possible the taking of decision on the basis of honest conviction, is the openness of men's minds, and the openness of whatever media there are for communion among men, free of restraint, free of repression, and free even of that most pervasive of all restraints, that of status and hierarchy."

Oppenheimer goes on to say (in 1953), "that we should all know—not precisely, but quantitatively and, above all, authoritatively—where we stand in these matters; that we should all have a good idea of how rapidly the situation has changed, and of where we may stand . . . three, four, or five years ahead."

With regard to the need for attaining freedom of action (i.e., to be able to negotiate with the Soviet Union), Oppenheimer says that candor is needed—"can-

dor on the part of the officials of the U. S. government to the officials, the representatives, the people of their country. We do not operate well when the important facts, the essential conditions, which limit and determine our choice are unknown. We do not operate well when they are known, in secrecy and in fear, only to a few men."

What Oppenheimer is pressing for is not a total slackening of the reins of secrecy; rather he seems to feel that in lifting many of the unnecessary embargoes on atomic information, all the nations of the world, in knowledgeable concert, will act to abolish the atomic Sword of Damocles and use nuclear power for the peaceful pursuits.

The remaining four lectures are entitled "Physics in the Contemporary World"; "The Encouragement of Science"; "The Scientist in Society"; and "Prospects in the Arts and Sciences".

A LOOK AT THE ARTS AND SCIENCES

Space does not permit adequate comment on Oppenheimer's views in these lectures. But the true nature of the man, as scientist and scholar, is revealed in a remark made in the concluding lecture (broadcast by CBS in December, 1954): "What does the world of the arts and sciences look like? There are two ways of looking at it: One is the view of the traveler, going by horse or foot, from village to village to town, staying in each to talk with those who live there, and to gather something of the quality of its life. This is the intimate view, partial, somewhat accidental, limited by the limited life and strength and curiosity of the traveler, but intimate and human, in a human compass. The other is the vast view, showing the earth with its fields and towns and valleys as they appear to a camera carried in a high-altitude rocket. In one sense this prospect will be more complete; one will see all branches of knowledge, one will see all the arts, one will see them as part of the vastness and complication of the whole of human life on earth. But one will miss a great deal; the beauty and warmth of human life will largely be gone from that prospect."

This book is the work of a man who has made significant contributions to science, to practical philosophy, and to the oft-scorned beliefs in human decency and forebearance among nations. His is the warm-hearted, compassionate view; for these and other reasons *The Open Mind* will appeal to every scientist who seeks to understand himself in relation to the new world he is instrumental in creating. Even more pertinently, it fixes, in time and space, the dominant role of the scientist in modern political, intellectual and social affairs.

Simon and Schuster, New York, N. Y. 146 pages, $2.75.

Helicopter Navigation Requirements

BY F. D. BARCLAY AND G. S. WILEY

All-weather operation of many large passenger helicopters in the near future will require new electronic navigation aids. By attempting to forecast requirements for design and demand for such aids for the years 1958 to '65, this book provides a valuable service to technical management in electronic groups.

In order to make these prophecies, the authors, both with Stamford Research Institute, made an intensive investigation of the multi-engine helicopter and its probable characteristics in the next 10 years. They also studied the area where helicopter service would be heaviest—Metropolitan New York. The results of both these studies are presented in separate chapters.

They conclude that helicopter navigation control is likely to be just as complicated as that for fixed-wing aircraft and that there is only a limited commercial market for the devices—about 560. Since the military will require most of the navigation aids produced, it would appear that the best course is to wait for the military to decide on the proper equipment, obtain that development contract and then hope to sell the commercial market a less expensive version of the military gear.

Another obvious deduction is that the device will be transistorized. Since the Navaid will not be needed in any number for five years or more, when the transistor will undoubtedly be a more ubiquitous and reliable device than at present, why bother with any vacuum-tube development?

The authors provide an extensive bibliography and a list of the expert persons contacted.

Available to qualified personnel by letterhead request to J. H. Overholser, Bendix Pacific Div., Bendix Aviation Corp., 11600 Sherman Way, N. Hollywood, Calif. 93 pages.

Reference Texts

ASME Handbook: Engineering Tables, Edited by Jesse Huckert, McGraw-Hill Book Co., West 42nd St., New York, N. Y., 704 pages, $12.00.

In this reference book, engineers and designers now have many tables of recognized design standards. Typical of these are the table of involute functions—methods for finding loads on ball bearings—and information on bars and tubes suitable for reworking into gears, levers, shafts or screws. Arranged in 15 sections, grouping together tables which apply to the design of specific parts.

Sources of Information and Unusual Services, 4th Edition 1956-57, Informational Directory Co., 200 W. 57th St., New York, N. Y., $2.00.

A guide to information, pamphlets and services available from organizations and agencies in the United States, including governmental and non-governmental organizations. More than 850 entries, 370 widely diverse subjects in fields related to business, health, science, recreation and education.

The ISCC–NBS Method of Designating Colors and a Dictionary of Color Names, NBS Circular 553, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., $2.00 ($2.50 foreign).

Four years of research has produced a dictionary of color names correlating the color terms used in different fields and relating all possible colors to a common, fundamental system of designation through combinations of 21 generic terms. It lists 7500 color names and defines them in simple, unambiguous terms, arranged to permit translation rapidly and accurately from one color vocabulary to another. Example: griseo-viridis (biology) is equivalent to serpentine (fashion), to mint green (mass market) and finally to light green (ISCC–NBS color designation).

Tables of Weber Parabolic Cylinder Functions, edited by J.C.P. Miller, Dept. of Scientific & Industrial Research, Charles House, 5-11 Regent St., London S.W.1., 140 pages, $11.34

Many problems in physics, engineering and mathematics can be dealt with by using the functions originally introduced by Weber for the solution of the wave equation in two dimensions in parabolic co-ordinates. This volume contains new tables of these functions based on Whittaker's form of the differential equation. Two independent solutions of the equation with various auxiliary functions to about eight significant figures.

X-Ray Protection, NBS Handbook 60, 41 pages, $0.20. (Order from Government Printing Office, Washington, D. C.).

The increasing use of high–energy X–rays in medicine and industry has presented problems in all phases of radiation protection and shielding. This handbook recommends general and specific applications of standards of safety set forth by the National Committee on Radiation Protection, and is intended for the protection of the radiation worker and the public.

Guide to Instrumentation Literature, NBS Circular 567, 156 pages, $1.00 (Order from Government Printing Office, Washington, D. C.).

This circular was prepared to assist research investigators, instrument users and others interested in utilizing the extensive and scattered literature of instrumentation. Over 1200 references are listed.

Research Reports

Reports in this section may be obtained directly from the Office of Technical Services, U.S. Dept. of Commerce, Washington, D. C., unless another source is stated.

Transistors, Cermets

Three new catalogs of technical reports on cermets, transistors and magnetic amplifiers are primarily the results of research done by the Government or by private laboratories with Government sponsorship, but also include German technical papers captured by the Allies in World War II. All applicable research reports in the OTS collection of documents are abstracted in the catalogs.

CTR-319 Cermets, CTR-310 The Transistor, and CTR-244 Magnetic Amplifiers, *$0.10 per copy.*

Nitric Acid Effects

Corrosion fatigue of various metals used in handling fuming nitric acid is the subject of this report. Investigations were made on RC-70 titanium, titanium alloy Ti-150-A, Armco 17-7PH stainless steel and 2S aluminum in white fuming nitric acid (1.5% NO_2) and red fuming nitric acid (10.5% NO_2 at room temperature.

Materials for Handling Fuming Nitric Acid and Properties of Fuming Nitric Acid with Reference to Its Thermal Stability, *PB 111877, 83 pages, $2.25.*

Titanium Welding

Processes for spot and seam welding of titanium and its alloys may be applied to production grades of commercially pure titanium sheet, the oxygen-nitrogen titanium-base alloy Ti-100A and the eight percent manganese titanium-base alloy. Simple welding equipment of the alternating current type is most suitable. Surface preparation treatments necessary only on heavily oxidized material.

Spot and Seam Welding of Titanium and Titanium Alloys, *PB 111707, 189 pages, $4.75.*

Nickel and High Nickel Alloys

A booklet summarizing important application requirements on adapting eight specific commercial high nickel alloys for pressure vessels is now available. The characteristics of these alloys are covered in the sections (1) The analysis and physical and mechanical properties of high nickel alloys, (2) Method of determining ASME Code design stresses, (3) Differences between these alloys and steel in fabrication, (4) Cold forming, hot forming and thermal treatments, (5) Procedures for cleaning, machining, welding and brazing by a variety of methods, (6) Some characteristics of the age-hardened alloys, (7) Inspection procedures.

Nickel and High Nickel Alloys for Pressure Vessels, *27 pages, no charge: Address requests to Reader Service Section, The International Nickel Co., Inc. 67 Wall St., New York 5, N. Y.*

Electron Tubes

Application information on 26 tube types in military equipment is designed to serve as a guide for the electronic equipment designer. In three parts: Discussion of properties common to all electron tubes; Effect of these properties in circuit design; Summary of application information with reference to specific categories of tubes. Mechanical, electrical and environmental information on specific tube types together with application notes and property behavior are also included.

Techniques for Application of Electron Tubes in Military Equipment, *PB 111644R, 295 pages, $5.00.*

Metal Alloys Studies

Two reports of Air Force research in metal alloys. In the first, data on damping, elasticity and fatigue of N-155 under rotating bending stress. Specimens were studied at room temperature, 1350° and 1500°F, and results compared on equal stress and equal stress ratio. The notched fatigue strength values obtained indicate a decreasing fatigue strength reduction factor as the temperature is raised.

Damping, Elasticity and Fatigue Properties of Unnotched and Notched N-155 at Room and Elevated Temperatures, *PB 111618, 77 pages, $2.00.*

In the second report, a study of fatigue characteristics in reversed bending of argon gas shielded tungsten-arc butt-welded joints in 14S-T and 75S-T sheet alloys. This welding process does not produce joints of satisfactory fatigue strength in these alloys. This appears to be a result of the alloy properties, not the process.

Fatigue Properties of Tungsten-Arc Butt-Welded Wrought Aluminum Alloys, *PB 111616, 27 pages, $0.75.*

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Teflon-Fiber Bearings 55

that are self-lubricating have bearing surface combining Teflon and cotton fibers laminated with phenolic resin. Already offered in automobile suspension joint by American Metal Products Co., Detroit.
E. I. du Pont de Nemours & Co., Inc., Wilmington 98, Del.

Miniature Oil-Hydrauiic Pump 56

for limited life airborne applications with unusually high power-weight ratios. Certain models are capable of developing more than 6hp per pound of total weight. Pump life and performance is consistent for inlet oil temperature conditions up to 200° F.
Vickers Inc., Box 302, Detroit 32, Mich.

Lithium Dispersions 57

can be used as catalysts in the production of the new "natural" rubber. Instruction sheets describe the methods for preparation of these lithium metal dispersions in such mediums as mineral oil, petrolatum and wax. Particle sizes in the range of 5 to 20 microns are possible.
Lithium Corp. of America, Inc., Minneapolis, Minn.

Here's a brief review of last month's advertising in RESEARCH & ENGINEERING as a service to readers.

Micro Technoscope 100

a stereoscopic binocular microscope for laboratory inspections and examinations. Rapid change to 6.3x, 10x, 16x, 25x, and 40x magnifications.
Carl Zeiss, Inc., 485 Fifth Ave., New York, N. Y.

Remote Control 101

provides friction-free movement of stainless steel blade in flexible tubing for heavy loads by means of ball bearing construction.
Controlex Corp. of America, Bldg., 4, Westchester County Airport, White Plains, N. Y.

High-Speed Photography 102

125 to 16,000 pictures per second, 100 to 500 ft. capacity. Also complete high-speed photography lab. Camera and lab described in free bulletin.
Wollensak Optical Co., 854 Hudson Ave., Rochester, N. Y.

Plant Size Reactors 103

have given high performance in many atomic energy projects. Available in standard or specially-designed reactors.
Autoclave Engineers, 2930 W. 22 St., Erie, Pa.

Nitroparaffins 104

and their derivatives are available in increasing quantities for solvents, prime ingredients, raw materials, sensitizers, emulsifiers, analytical reagents, reducing agents.
Commercial Solvents Corp., 260 Madison Ave., New York, N. Y.

Permanent Magnets 105

have undergone 13 tests including Spectograph tests, chemical analyses, Zyglo tests, and are available in wide variety of sizes, grades, and magnet materials.
The Indiana Steel Products Co., Valparaiso, Ind.

Applications for Lithium 106

in organic chemistry, metallurgy, inorganic chemistry, and heat transfer described in bulletin. Experimental quantities of Lithium compounds available on request.
Lithium Corp. of America, Inc., 2697 Rand Tower, Minneapolis 2, Minn.

Electron Microscope 107

for fundamental research on crystalline structures, diverse solids, metallurgical and geological specimens.
Radio Corp. of America, Dept. E-281, Camden, N. J.

Use for Cerium Oxide 108

as polishing agent for all types of mirrors and precision optical lenses, and for coloring and decolorizing glass described in free bulletin.
Lindsay Chemical Co., 274 Ann St., West Chicago, Ill.

Abrasive Method 109

gas-propelled, produces no heat, shock or vibration. For cutting, grooving, trimming in both lab and pilot plant.
S. S. White Industrial Div., Dept. 11, 10 E. 40 St., N. Y. C.

Special Diecasting 110

of small parts is described in bulletins on diecasting, plastic molding, industrial fasteners, gear and pinions, standard parts.
Gries Reproducer Corp., 134 Beechwood Ave., New Rochelle, N. Y.

Electronic Components 111

including tuning circuits are the specialty of this firm's research engineering staff for electronics.
Standard Coil Products Co., Inc., Melrose Park, Ill.

Gas Chromatography 112

aids in three types of "Woelm" alumina—basic, neutral and acid for analysing natural or synthetic compounds.
Standard Scientific Supply Corp., 34 W. 4 St., N.Y.C.

Consulting Service 113

in research and technology described in booklet *Problem Solving—The Businessman's Guide to Seeing Alternatives.*
Arthur D. Little, Inc., 30 Memorial Dr., Cambridge, Mass.

Additional Information Form

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For more information on products or copies of literature described in the Product Portfolio or in advertisements in this issue, circle the appropriate code number below.

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